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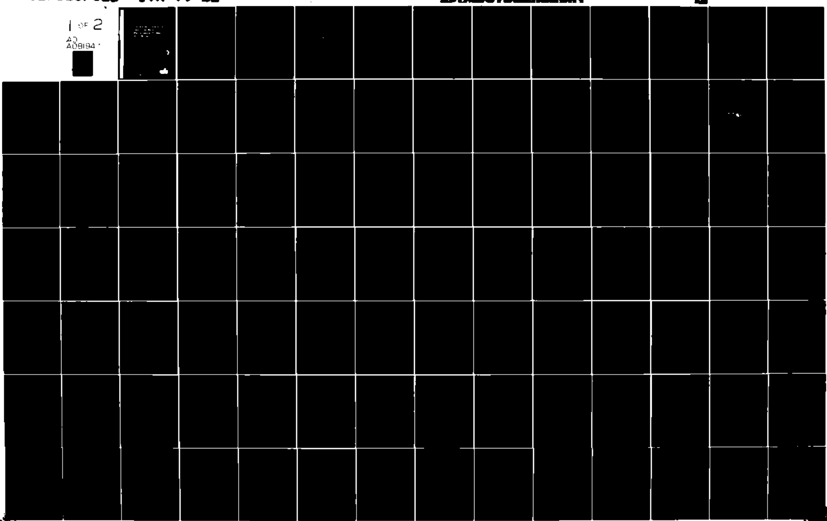

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Performance Assessment Laboratory, Department of Psychology
Old Dominion University, Norfolk, Virginia 23508

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Physiological Influences Upon The Work Performance Of Men And Women

By

Glynn D. Coates,
Raymond H. Kirby,
Nancy K. Eberhardt,
and
Sarah J. Miller

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The synthetic-work methodology of the Multiple Task Performance Battery (MTPB) was employed in a series of studies designed to determine the effects of 48 hours of continuous work and sleep loss on the work performance of four groups of female subjects and one group of male subjects. The specific female groups were defined in the design by a factorial combination of the phase of the menstrual cycle at the beginning of the sleep-loss period (i.e., Menstrual vs Mid-Cycle) and whether or not the subjects were using contraceptive pills (i.e., Pill vs Normally Cycling). The performances of these four groups of

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female subjects were compared with those of a group of male subjects who performed the tasks of the MTPB under identical conditions; comparisons were performed during training, during a baseline period, during the sleep-loss, continuous-work period, and during a post-recovery period. An extension of these studies subsequently compared the performances of two groups of female subjects (i.e., Normally Cycling and Pill) for an additional five weeks under normal work conditions; the purpose of this extension was to assess the effects of the phases of the menstrual cycle on work performance.

The results revealed no significant differences among the work performances of the five groups during training, the baseline period, during the first 32 hours of sleep or during the post-recovery period. However, differences were noted during the final 16 hours of the sleep-loss and continuous-work period. Specifically, the maximum performance decrements observed for the groups were 18.1% of baseline performance for the Normal Menstrual group, 24.3% for the Normal Mid-Cycle group, 30.4% for the Pill Menstrual group, 36.7% for the Pill Mid-Cycle group, and 33.9% for the Male group; the differences between the last two groups and the Normal Menstrual group were statistically significant. The tendency for the normally cycling females to be more resistant to the effects of sleep loss than the Pill females and males was discussed as was the tendency for the menstrual groups to be more resistant than the mid-cycle groups. The cycling extension of these studies revealed little evidence of an effect of the phases of the menstrual cycle on normal, non-stressed performance. The need for additional investigations involving the parameters of these studies was emphasized.

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PHYSIOLOGICAL INFLUENCES UPON THE WORK PERFORMANCE OF MEN AND WOMEN

By

(10)

Glynn D. Coates, Raymond H. Kirby,
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FOREWORD

This report was prepared by Drs. Glynn D. Coates (Professor of Psychology), Raymond H. Kirby (Chairman and Professor of Psychology), Ms. Nancy K. Eberhardt, and Ms. Sarah J. Miller, Performance Assessment Laboratory, Department of Psychology, Old Dominion University, Norfolk, Virginia 23508. Certain of the appendices were prepared by others who are listed there and in the Table of Contents. The work reported is a research program supported by the U.S. Air Force Office of Scientific Research under Grant No. AFOSR-78-3512, "Physiological Influences Upon the Work Performance of Men and Women," monitored by the Life Sciences Directorate, Air Force Office of Scientific Research, Bolling Air Force Base, Washington, D.C. 20332.

The authors wish to acknowledge with gratitude the assistance of Dr. W. L. LeHew, Department of Obstetrics and Gynecology, Eastern Virginia Medical School, who served as medical consultant for this project; without his willingness to interrupt his busy schedule to schedule gynecological exminations for our subjects on very short notice, the project would most certainly have faltered.

The authors wish to acknowledge also the research assistants who contributed to the project through the numerous hours of data collection, summarization, and analysis--Ruth Brogan, Ray Comstock, Linda Cruser, Lynda Eatherly, Coleen Gilmore, Jerry Hedge, Patricia Jaudon, Susan Love, D.M. McAnulty, Denise Murdoch, Joan Nixon, Rita Planas, and Gordon Warstler as well as the secretarial staff that supported the project--Judith Grimes, Jean Hopkins, and Sarah Sands.

Finally, the authors' wish to express their appreciation to the subjects who served in these studies. A total of 40 female undergraduates at Old Dominion University who volunteered to serve in the studies of this project and 10 male undergraduates at the University of Louisville who volunteered to serve in earlier projects deserve the gratitude of all of us. Their contribution--the performance that provided the data reported--is quite obviously a significant and important part of the research.

* * * * * * * * *

SUMMARY

The synthetic-work methodology of the Multiple Task Performance Battery (MTPB) was employed in a series of studies designed to determine the effects of 48 hours of continuous work and sleep loss on the work performances of four groups of female subjects and one group of male subjects. The specific female groups were defined in the design by a factorial combination of the phase of the menstrual cycle at the beginning of the sleep-loss period (i.e., Menstrual vs Mid-Cycle) and whether or not the subjects were using contraceptive pills (i.e., Pill vs Normally Cycling). The performances of these four groups of female subjects were compared with those of a group of male subjects who performed the tasks of the MTPB under identical conditions; comparisons were performed during training, during a baseline period, during the sleep-loss, continuous-work period, and during a post-recovery period. An extension of these studies subsequently compared the performances of two groups of female subjects (i.e., Normally Cycling and Pill) for an additional five weeks under normal work conditions; the purpose of this extension was to assess the effects of the phases of the menstrual cycle on work performance.

The results revealed no significant differences among the work performances of the five groups during training, the baseline period, during the first 32 hours of sleep or during the post-recovery period. However, differences were noted during the final 16 hours of the sleep-loss and continuous-work period. Specifically, the maximum performance decrements observed for the groups were 18.1% of baseline performance for the Normal Menstrual group, 24.3% for the Normal Mid-Cycle group, 30.4% for the Pill Menstrual group, 36.7% for the Pill Mid-Cycle group, and 33.9% for the Male group; the differences between the last two groups and the Normal Menstrual group were statistically significant. The tendency for the normally cycling females to be more resistant to the effects of sleep loss than the Pill females and males was discussed as was the tendency for the menstrual

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INTRODUCTION

Sex Differences in Performance

In recent years, questions concerning possible sex differences have been raised in a number of different areas. Although these questions have been expressed in a variety of ways, the question that guided the conduct of the present project is best expressed as "Are there clear-cut behavioral and performance differences between males and females, and how might these differences affect work performance?" A sizable literature exists that indicates that there are clear differences between the sexes in the cognitive/sensory-motor abilities. As a result of their literature in this area, Broverman, Klaiber, Kobayashi, and Vogel (1968) proposed a conceptual dichotomy of simply perceptual-motor tasks versus inhibitory perceptual-restructuring tasks to account for the observed behavioral differences. This dichotomy follows similar earlier treatments of the data (cf. Anastasi and Foley, 1949; Witkin, Dyk, Faterson, Goodenough, and Karp, 1962).

Males have been found to excel at those tasks requiring inhibitory perceptual restructuring. Such tasks involve (a) an inhibition or delay in responding to salient cues in favor of less salient stimuli, (b) a higher order of processing in constrast to simple reflexive behaviors, and (c) tasks that require novel solutions or a reorganization of material. In partial support of this analysis, males perform better on the Rod-and-Frame Test which requires the subject to ignore irrelevant information (the orientation of the frame) while estimating the angle of the rod. Females are more likely to use the frame as a reference and, thereby, fail to assess properly the orientation of the rod (Bennett, 1956; Silverman, Buschsbaum, and Stierlin, 1973).

In contrast, females are more proficient on tasks that (a) are largely based on prior learning, (b) involve minimal cognitive processing and are primarily reflexive, (c) involve fine muscular control, and (d) involve repetition requiring speed and accuracy. Males, for example, are superior at maze solving (Porteus, 1918), object assembly (Anastasi and Foley, 1949; Wechsler, 1955), and at locating hidden figures (McNemar, 1942), while females are superior at color naming (Stroop, 1935), digit symbol substitution (Gainer, 1962; Miele, 1958), fine manual dexterity (Tiffin and Asher, 1948), eyelid conditioning (Spence and Spence, 1966), and evidence greater auditory and taste sensitivity (Corso, 1959; Soltan and Bracken, 1958).

Effects of Menstrual Cycle on Performance

The above research results pertain to differences between the sexes with no attention given to the potential effects of cyclical hormonal changes that occur in females (i.e., the menstrual cycle). A large literature has developed concerning the changes in cognition and behavior that occur as a function of the various phases of the menstrual cycle. Generally, these studies divide the menstrual cycle into at least three phases--menstrual, midcycle, premenstrual--although some deal only with menstrual versus nonmenstrual phases. A large segment of this literature will not be treated here since it pertains primarily to the affective changes that coincide with the menstrual cycle phases and do not include data regarding performance changes. (For a review of this segment of the literature, see Parlee, 1973).

In the behavioral category, there are a number of reports that suggest a degradation in functioning during the premenstrual/menstrual phases of the cycle. During these phases, accident rates are reported to peak (Dalton, 1960), deaths from accidents and suicide increase (MacKinnon and MacKinnon, 1956; Mandell and Mandell, 1967), admissions to mental hospitals for acute emotional disturbances increase (Dalton, 1959), and the commission of violent crimes increases (Cooke, 1945; Moton, Additon, Hunt and Sullivan, 1953; Ribiero, 1962), athletic competition suffers (Brunnelli and Rottini, 1965; Fichera and Romano, 1956; Noack, 1960), and misconduct in female prisoners and students increases (Dalton, 1964).

There are numerous problems with this litany of disturbances, one of which is that many of the studies have serious methodological shortcomings, as has been well documented by Parlee (1973). In addition, the literature contains several conflicting findings. For instance, Bausenwein (1960) reported that some of the best performances by Olympic athletes occurred during menstruation. Dalton (1968) reported a drop in test scores among 1959 school girls during menstrual and premenstrual phases, whereas others have failed to find any changes in performance on mental tests as a function of cycle phase (Vernon and Parry, 1949; Wickham, 1958). Zimmerman and Parlee (1973) found no differences in autonomic arousal (GSR), digit symbol (WAIS) scores, reaction times, or time estimation over the menstrual cycle. However, they did report increased arm steadiness during the luteal phase (i.e., 4 to 5 days after ovulation), and decreased steadiness during menstruation. In contrast, other researchers failed to find any effect of the cycle on reaction times (Kopell, Lunde, Clayton, and Moos, 1969; Southam and Ganzaga, 1965), or on intellectual performance (Sommer, 1972).

Sensory thresholds appear to fluctuate as a function of menstrual cycle phase with the greatest sensitivity reported at ovulation and the lowest at menstruation—vision (Diamond, Diamond, and Mast, 1972); audition (Semeczuk, Prezesmyeka, and Pomykalski, 1967); cold (Schneider and Wolff, 1955); and olfaction (LeMagnen, 1952; Schneider and Wolff, 1955). Pain thresholds also vary as a function of the cycle, but the pattern is reversed with the poorest sensitivity occurring at ovulation (Buzzelli, Voegelin, Procacci, and Bozza, 1968). With the exception of the pain threshold, these studies indicate a clear degradation in sensitivity during menstruation. Unlike this pattern, women using oral contraceptives do not show these sensory fluctuations (Diamond, Diamond, and Mast, 1972; Procacci, Corte, Zappi, and Marersea, 1974). The "pill" also appears to eliminate the cyclical mood changes ("premenstrual syndrome") normally reported (Paige, 1971).

One difficulty in interpreting or translating these prior findings into a "real world" job setting is the restricted nature of the tasks used. Most of the tasks used are of relatively short duration (e.g., eyeblink conditioning, maze solving), and probably are not relevant to performance effectiveness under a continuous or prolonged work schedule. In a recent bibliographic review of 217 articles entitled Women and Work, only 12 articles were classified as pertaining to performance, and of those none was related to job performance (Nieva and Gutek, 1976). The literature concerning work performance is extremely variable. Redgrove (1971), for example, found no relationship between cycle and laundry work or typing. Farris (1956) observed 10 women over two cycles and found three peaks in industrial output at days 4, 12, and 25 of the 30-day cycle. Johnson (1932) reported a drop in tight wire learning during menstruation. Further, others have reported drops in efficiency in industrial settings during menstruation (Anon., 1970; Gorkine and Brandis, 1936). In contrast, Lewin and Freund (1930) found no change in the quality of work, but an increase in speed and a drop in persistence during menstruation. A study of industrial absenteeism of 91 women over 3800 working days failed to find any clear-cut relationship between menstrual phase and absenteeism (Smith, 1950).

In summary, there have been numerous studies that have catalogued the differences that exist between the sexes with respect to performances on a wide range of tests and measures of sensitivities, functions, and abilities. Likewise, numerous studies have identified a variety of tests behaviors that appear to fluctuate as a function of the menstrual cycle in females, although contradictions are prevalent within these data. However, if one adopts even the most optimistic position with respect to the interpretation of these findings, they offer little or nothing in terms of predicting differential performances in a work situation. The complexities of the work situation, in terms of the combinations of sensitivities, functions, and abilities involved, coupled with the overlearning inherent in the work situation have, for the most part, rendered the findings with respect to isolated test behaviors useless for predicting any aspect of work performance.

The approach taken in the present project was to employ a "work" situation in an attempt to obtain data that are applicable to the work situation in the real world. Specifically, the synthetic-work methodology was employed throughout the project. The standardized procedures of the synthetic-work approach to performance assessment (cf. Alluisi, 1969; Chiles, Alluisi, and Adams, 1968; Morgan and Alluisi, 1972) have been used for more than a decade to assess (i.e., measure and evaluate) the performances of men at work (cf. Alluisi, Beisel, Bartelloni, and Coates, 1973; Beisel, Morgan, Bartelloni, Coates DeRubertis, and Alluisi, 1974; Chiles, et al., 1968; Morgan, 1974).

<u>The Multiple-Task Performance Battery (MTPB)</u>

The synthetic-work approach employs a Multiple-Task Performance Battery (MTPB) to create within the laboratory a synthetic-work situation in which systematic assessments of work behavior can be made. The MTPB calls for the time-shared performance of six tasks that were selected to represent processes typically demanded of persons in real work. It is contended that the measured performances belong to the domain of work behavior, and that they differ considerably from the test behaviors more often studied by psychologists (see Chiles, 1967; Dunnette, 1963). In short, in the synthetic-work methodology, a job or work situation has been synthesized, and the human subject is called upon to perform on this job as he or she would on any other job. Measurements of performance are made during the acquisition of skill on this job (training) as well as during later periods of asymptotic performance (work). (It should be noted that previous data indicate that a training period of approximately 48 hours is required to achieve asymptotic levels of performance.) These measurements may be used to constitute a behavioral assessment of the efficiency of training and of work performance under normal or stressful conditions.

The six tasks included in the current version of the MTPB were selected to test both individual and small-group (crew) performances. They were also chosen to meet certain criteria of validity, sensitivity, engineering feasibility, reliability, flexibility, workload variability, trainability, and control-data availability (cf. Alluisi and Fulkerson, 1964, pp. 5-6). All of the selected tasks show very high reliabilities and have done so since their earliest use (cf. Adams, Levine, and Chiles, 1959; Alluisi, Hall, and Chiles, 1962; Alluisi and Fulkerson, 1964).

The synthetic-work approach and its MTPB have been used previously in studies of (a) work-rest scheduling (Chiles, et al., 1968); (b) the behavioral effects of infectious disease (Alluisi, et al., 1973) and the influence of symptomatic treatment (Beisel, et al., 1974); (c) the effects of from 36 to 48 hours of continuous work and sleep loss (Morgan, 1974; Morgan, Brown, and Alluisi, 1974); as well as (d) the potential of biofeedback autoregulation techniques to prevent the performance decrements that usually occur with such sleep loss (Coates, Kirby, and Morgan, 1975); (e) the selection, training, and operations of air traffic controllers (Chiles, Jennings, and West, 1972; Chiles and West, 1974); and (f) the behavioral effects of occupational exposures to toxic substances such as lead (Repko, Morgan, and Nicholson, 1974).

Obviously the past research has been primarily concerned with the effects of various stress conditions on postacquisition, asymptotic (work) performances. On the not so obvious side, however, is the fact that all of the above research, conducted with the MTPB over more than 15 years, has employed male subjects only. Indeed, data collection conducted within this project represents the only data obtained from female operators in the widely used synthetic-work situation.

The present project, therefore, was designed to provide performance data of female workers in a work situation (as distinguished from a test situation) that would permit a number of timely comparisons that hopefully would be relevant to work performances in the real world. Specifically, the project was designed to provide reliable quantitative measures of work performances of both male and female workers so as to permit comparisons of (a) asymptotic levels of work performance in males and females, (b) the effects of 48 hours of continuous work and sleep loss on the work performances of males and females, (c) the effects of phases of the menstrual cycle and 48 hours of continuous work and sleep loss on the work performances of females who are using contraceptive pills and females who are not using contraceptive pills, and (d) the work performances during a one-month period of females who are using contraceptive pills and females who are not using contraceptive pills.

Method

The data presented in this report consist of data collected under two sources of support. The data of the female subjects were collected under support of the present grant and were obtained in a series of 7 studies, hereafter referred to as the BRASP studies for (Biological Rhythms And Sustained Performance). The data of the male subjects were collected as part of a project supported by the Army Research Office under Army THEMIS Contract Number DA HC19-69-C-0009; these data will hereafter be referred to as the SPADE data (for Studies of Performance Assessment anD Enhancement). The latter data have been previously reported in detail (cf., Morgan, Brown, and Alluisi, 1970; Morgan, Brown, and Alluisi, 1974) and have been employed in this report to provide the male comparison data for this project.

Design

As noted above, the BRASP series consisted of 7 studies, the first 6 of which were conducted in three phases, with the last study consisting of only the first two phases.

Training Phase.--Phase 1, or the Training Phase of each study consisted of 48 hours (i.e., 24, 2-hour periods) of performance on the MTPB during which the subjects performed the tasks of the battery for four continuous hours per day for 12 days. The 12 days were generally distributed over four weeks during which the subjects worked for three days each week, although distribution of the twelve days could have been achieved within a two-week period of six days per week. Past research with the MTPB has established that 48 hours of training with the tasks of the battery are necessary in order for the subjects to reach asymptotic levels of performance in the time-sharing requirements of the battery.

Sleep-Loss Phase.--Phase 2 of each of the studies followed the procedures previously employed in similar studies with male subjects. Specifically, seven consecutive days were required for this phase with the first two days providing 16 hours of baseline performance, the last two days providing 16 hours of recovery data, and the middle three days providing 48 hours of continuous-work and sleep-loss data followed by 24 hours of rest and recovery. Consequently, on Monday and Tuesday of each sleep-loss week, subjects were required to work for 8 hours each day following a 4-4-4-12 work-rest schedule (i.e., 4 hours on duty, 4 hours off, 4 on, and 12 off). The beginning of each continuous-work period began at 0800 hours on Wednesday, and subjects were required to work at the MTPB for 48 continuous hours for a total of 24 cycles through a basic 2-hour performance period. Immediately following the period of continuous work (i.e., at 0800 hours on Friday), subjects received 24 hours of rest and recovery, the first 12 of which was spent under supervised sleeping conditions in the Performance Assessment Laboratory. Subsequent to the rest-and-recovery period, the subjects were required to perform the tasks of the MTPB for two additional days following the 4-4-4-12 work-rest schedule.

The data of the male subjects, collected under the SPADE series, were collected under conditions identical to those outlined above for Phases 1 and 2--the Training and Sleep-Loss phases.

Cycling Phase.--During Phase 3 of each study (for the first 6 studies of the BRASP-series), the Cycling Phase, the subjects performed the tasks of the MTPB for five additional weeks with 12 hours per week of performance in blocks of four continuous hours. The distribution of the three work periods within each week was spread as much as possible through the week so as to provide adequate sampling of any changes that may have occurred during the testing period.

Experimental Design.--Although the data reported herein were collected in a series of 7 BRASP studies and the equivalent of 2 SPADE studies, the data collection and selection of subjects was guided by a design calling for training and sleep-loss data under identical conditions for five groups of subjects. Specifically, for the training and sleep-loss data, the experimental groups were:

1. Females who were cycling without contraceptive pills and who were, at the beginning of the continuous-work period (i.e., 0800 hours on Wednesday of the Sleep-Loss Week), approximately midway through the menstrual cycle. This group of subjects will be referred to as Normal Mid-Cycle.
2. Females who were cycling without contraceptive pills and who were, at the beginning of the continuous-work period, approximately at the beginning of their menstrual cycle. This group of subjects will be referred to as Normal Menstrual.
3. Females who were using contraceptive pills and who were, at the beginning of the continuous-work period, approximately midway through the menstrual cycle. This group of subjects will be referred to as Pill Mid-Cycle.
4. Females who were using contraceptive pills and who were, at the beginning of the continuous-work period, approximately at the beginning of their menstrual cycle. This group of subjects will be referred to as Pill Menstrual.
5. Males who served as subjects in the SPADE series of studies and who performed under procedural conditions identical to those employed with the female subjects. This group of subjects will be referred to as Males.

The goal was to solicit subjects so as to construct the above five groups with approximately equal numbers of subjects. However, due to the extreme variability of the menstrual cycles, both between and within subjects, coupled with the fact that subjects had to be selected approximately four weeks prior to the target date (i.e., beginning of the continuous-work period), equal N's for the five groups were not possible. The total number of subjects whose data are reported herein were 7, 5, 8, 8, and 10 for the Normal Mid-Cycle, Normal Menstrual, Pill Mid-Cycle, Pill Menstrual, and Males, respectively. Details concerning these subjects will be presented below.

The five groups and the particular conditions were selected so as to permit comparisons between groups at baseline levels of performance and to permit between-group as well as within-group comparisons during the continuous-work and sleep-loss and recovery periods.

The design further called for two groups of subjects to be included in the Cycling Phase of the project. Specifically, a group of females who were not using contraceptive pills (Normally Cycling) and a group of females who were using contraceptive pills (Pill Cycling) were required to perform the MTPB for a duration that would cover an entire menstrual cycle. Again, the goal was equal numbers for the two groups of subjects and this goal was achieved with an N = 15 for each of the two groups. As indicated above, these subjects were subjects who had previously served in Phases 1 and 2; since the onset of the Cycling Phase began during the week immediately following the Sleep-Loss Week, the particular phase of the menstrual cycle for each subject was determined by the selection requirements of the previous two phases. Specifically, at the beginning of the Cycling Phase, each subject was approximately 7 days later in her menstrual cycle than she was during the Sleep-Loss phase. These two groups of subjects were selected to permit between-group comparisons of performances at various phases of the menstrual cycle.

Subjects

A total of 40 female undergraduate students at Old Dominion University served as subjects in the BRASP studies; the data for 12 of these subjects are not included in this report because of menstrual cycle irregularities and failure to meet menstrual cycle criterion at the beginning of the continuous-work period. Table 1 presents descriptive data of the 28 subjects whose data are reported herein; the table presents N, mean age, mean height, mean weight, mean cycle length of menstrual cycle during continuous work, and mean day of cycle at the beginning of the continuous-work period (Day 1 is the onset of menstruation).

Table 1

Summary Statistics for Subjects of the BRASP Studies

Group	N	Age	Height	Weight	Cycle Length	Day of Cycle
Normal Mid Cycle	7	20.57	63.29	117.71	30.71	17.86
Normal Menstrual	5	20.40	64.60	116.00	29.40	1.20
Pill Mid Cycle	8	20.25	65.75	125.00	28.00	17.38
Pill Menstrual	8	20.00	63.75	112.75	28.75	1.62

Prior to selection, each subject received a complete physical with gynecological examination. Detailed descriptions of each of the 40 subjects are presented as Appendix C to this report.

The subjects serving in the SPADE series were ten male undergraduate students at the University of Louisville who were selected for participation from a group of volunteers from the Navy and Air Force ROTC units. The mean age of these subjects was 20.25 years.

All subjects were hired to work as participants in these projects. They were selected according to the criteria specified and randomly assigned to work in crews of five persons. The senior person on each crew was designated crew commander.

Apparatus

The principal behavioral measures in these studies were obtained from the subjects' performances of the six tasks presented with the MTPB. The tasks were displayed on each of five identical operator panels (one for each member of a five-person crew). A schematic of the front of one of these panels is presented in Figure 1.

Three watchkeeping tasks were used to measure each subject's performance of watchkeeping, vigilance, or attentive functions (blinking-lights, warning-lights, and probability monitoring). Three active tasks were used to measure his performance of memory functions (arithmetic computations), sensory perceptual functions (target identification), and procedural functions (code-lock solving). Since all of the tasks have been described fully in previous publications (e.g., Adams & Chiles, 1961; Alluisi, 1969; Chiles, Alluisi, & Adams, 1968; Morgan & Alluisi, 1972), they will only be briefly identified here (more complete descriptions are given in Appendix A).

The three watchkeeping tasks are performed continuously. Warning-lights monitoring requires that the subject respond to the relatively infrequent lighting of a red light or extinguishing of a green light. Blinking-lights monitoring requires that the subject respond to the relatively infrequent arrest of alternation of two amber indicator lights. Probability monitoring represents a watchkeeping task of a more complex nature that requires the subject

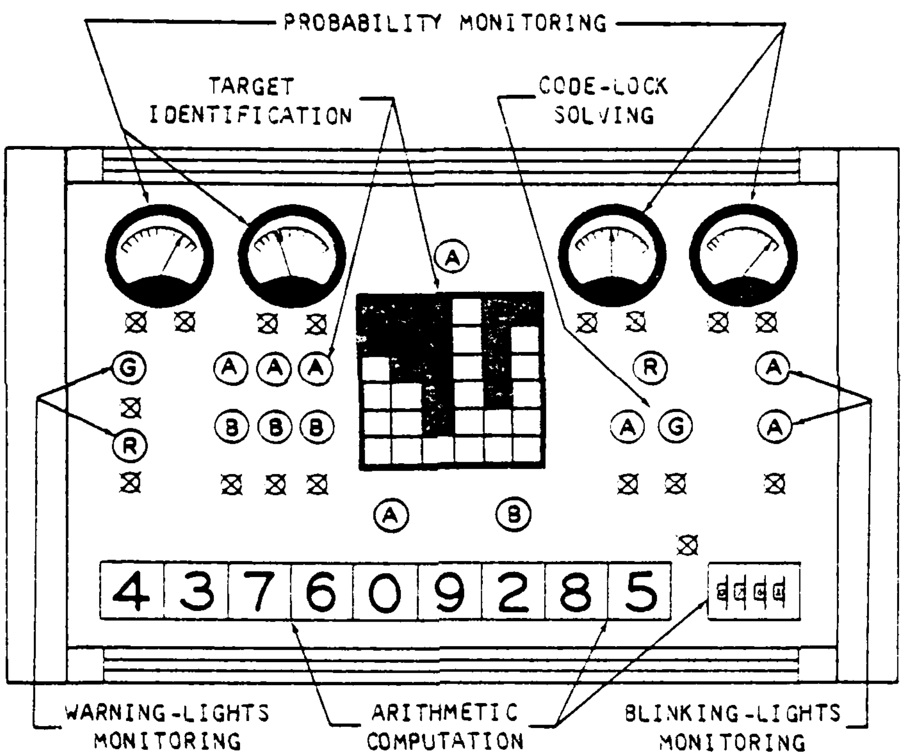

Figure 1: Schematic diagram of the front view of an MTPB operator panel. Letters in circles represent indicator lights: A--amber, B--blue, G--green, R--red. The smaller circles with crossing diagonals represent pushbuttons.

to integrate over time the movements of four meter pointers, controlled by a random process, in order to detect a relatively infrequent shift in the mean value of the process (i.e., a shift in the mean pointer position from vertical to a right or left deviation equivalent to about one standard deviation unit of the random process).

Two of the three active tasks are experimenter paced. The arithmetic computations task requires that the subject add a 3-digit number to another 3-digit number and then subtract from the sum a third 3-digit number. Neither paper and pencil nor any other memory aid is permitted. This task is paced at a rate of 3 problems per minute during the 30 minutes of its presentation in each 2-hour performance period.

The target-identification task requires that each subject report a judgment as to whether the first, the second, or neither of two possibly rotated "sensed-choice" images is the same as a previously displayed nonrotated "stored-target" image. This task is paced at a rate of 2 problems per minute during the 30 minutes of its presentation in each 2-hour performance period.

The third active task is a group-performance or crew task ("code-lock solving") that is time-shared with each of the other tasks during part of the two-hour performance period; it requires the five crew members to work cooperatively in order to achieve group solutions to problems. Specifically, the task requires that subjects discover the correct sequence in which each of five buttons (one at each operator position) has to be pushed to illuminate a green light. The subjects are required to respond to this task as quickly as possible without neglecting their other concomitant duties. Thus, although not paced by the apparatus or the experimenters, neither is the task entirely unpaced for the individual crewmember, who has a "time" to respond and upon whose response the rest of the crew depends! This task is presented during 60 minutes of each

2-hour performance period; it overlaps with arithmetic computations and with target identification for 15 minutes each, and is presented "alone" (i.e., with no other active task, but only with the 3 watchkeeping tasks) during the remaining 30 minutes.

Task Program

While on duty in the work-station area, the subjects worked the MTPB tasks according to a basic two-hour task program. This program, which is shown in Table 2, provides scheduled periods of different relative demands on performance and was designed to be as comparable as possible to the program used in earlier studies of sustained performance with the synthetic-work methodology (cf. Alluisi, Coates, & Morgan, 1977; Beisel, Morgan, Bartelloni, Coates, De Rubertis, & Alluisi, 1974; Chiles, Alluisi, & Adams, 1968; Morgan, 1974).

As shown in Table 2, there are 30 minutes of low-demand performance, 60 minutes of intermediate-demand performance, and 30 minutes of high-demand performance during each 2-hour period of testing. From the subject's viewpoint, there is no break between repetitions of the program from the start to the end of a testing session or "work day," since the three watchkeeping tasks are presented continuously at each work station.

Table 2. Basic 2-Hour Task-Performance Schedule.

	15-Minute Interval in Each 2-Hour Period							
Performance Task	1	2	3	4	5	6	7	8
Blinking-Lights Monitoring	X	X	X	X	X	X	X	X
Warning-Lights Monitoring	X	X	X	X	X	X	X	X
Probability Monitoring	X	X	X	X	X	X	X	X
Arithmetic Computations		X	X					
Code-Lock Solving			X	X	X	X		
Target Identification						X	X	
Level of Demand	Low	Med	High	Med	Med	High	Med	Low

An amber light on each panel signals that the arithmetic-computations task will begin in 30 seconds, and a second amber light provides a similar 30-second warning for target identification. In addition, the green light used with the code-lock task is illuminated 30 seconds prior to the beginning of the first problem of that task. The subjects were told that their performances were being scored continuously, as indeed they were, but analyses have been made only of the data obtained during the 90-minute intermediate-demand and high demand performance periods in each 2-hour period of testing.

General Procedure

Each of the 5-person crews was tested within an experimental room (approximately 2.74 by 4.57 meters) in which each subject sat in a semi-enclosed booth. These booths were approximately 1-meter wide, enclosed on 3 sides with walls approximately 1.5 meters high and 1.5 meters deep. Broadband noise of approximately 70 dB in intensity was employed in the experimental room during all periods of training and testing in order to mask extraneous sounds, including the sounds made by the programming equipment.

Physiological Measures

The performance measures obtained with the MTPB were supplemented with two psychophysiological measures: body temperature and pulse rate. Oral temperatures were measured by the subject. The temperature and pulse data were recorded at the end of each 2-hr. period of performance and were analyzed like the performance data. In addition, throughout the course of the study each subject took her basal body temperature orally upon arising in the morning. A log of these data and her menstrual history was turned in to one of the female experimenters each week.

Orientation and Training

Prior to initial familiarization with the MTPB, the subjects attended a 2-hour briefing concerning the research project and test plans. Attention was directed during the orientation and training periods to the objectives of the study. All subjects were shown the diurnal variations in performance and physiological activation that had been evidenced in a prior study (Adams & Chiles, 1961), and they were told that similar variations would occur in their own performances unless they expended extra energy during the periods of low physiological activation. These instructions were presented as a standard operating procedure. In addition, the importance of concerted effort during all phases of testing was emphasized. The schedule of training and performance testing is included in Appendix B.

Physical conditions in the experimental areas were arranged so that the subjects could interact only with the project director and the two chief experimenters who served as shift leaders (the authors) throughout the training and testing periods. A cordial, but semiformal and business-like relation was established and maintained between the subjects and the experimenters at all times. Questions and comments were encouraged, and every attempt was made to dispel any uncertainty, doubt, or fear that may have developed concerning the nature of the tests and the performance required for operation of the MTP battery.

Pretest interviews were held privately with the individual subjects to provide opportunities for the expression of any anxieties concerning participation in the performance-testing aspects of the study (none was evidenced) and, further, to obtain information concerning the subject's age, marital status, menstrual history, etc. The rapport between the experimenters and the subjects was excellent during both training and testing. This was confirmed by experimenter observations, voluntary comments of subjects, and the responses of subjects to questions asked during post-test debriefing interviews.

Testing

The subjects were given instructions concerning all procedures related to the test conditions, including those incidental to the actual performance testing.

For example, standard operating procedures were established for use of the intercom system. In general, standard radio procedure was followed. The test crews were designated "BRASP-1," and the experimenter station was designated "BRASP CONTROL." The subjects were instructed to keep intercom conversation to a minimum, and the only calls permitted between the subjects and BRASP CONTROL were "business" calls such as those required to report an apparent malfunction of equipment. Whenever BRASP CONTROL called the crew, the call was addressed to the crew commander; if another member of the crew was to be called, the crew commander was contacted who relayed the message to the specific crewmember. The intercom system was a "common-line" system in which all stations (including the experimenter, or BRASP CONTROL) received all communications.

A "standard operating procedure" (SOP) was read to each crew prior to its first duty period and again after approximately 30 hours of training. The SOP was intended as a summary of the procedures established during the orientation and training. The SOP is presented below:

> 1. The test is made up of both individual-performance tasks (i.e., blinking-lights, warning-lights, and probability monitoring, arithmetic computations, and target identifications) and a crew-performance task (code-lock solving). Each crewmember is to work alone on the individual-performance tasks, without giving or receiving help, hints, or cues from any other crewmember. Crewmembers are expected to work together on the code-lock task; there it is expected that performance will show cooperation, coordination, and the proper exchange of all necessary information among crewmembers.
>
> 2. Should a crewmember discover a way to "beat the computer," he/she is not to use the "trick" if he/she can avoid it. Its use would serve only to invalidate the results of the test. Rather, he/she should notify BRASP CONTROL (through the Crew Commander, or directly, with permission) so that corrective action can be taken.
>
> 3. Standard radio procedures will be followed in using the intercom. Interstation conversation should be kept to a minimum.

4. All requests for relief are to be made to the Crew Commander, and then only when necessary. Relief from duty stations will be limited to the 1/2-hour low-performance periods, and then only for emergency conditions. Verbal report to the Crew Commander will be made by intercom upon leaving the duty station and again upon return to the duty station.

5. In case of malfunction of the equipment, report should be made to the Crew Commander or (when authorized by him/her) directly to BRASP CONTROL.

Broad-band noise of approxiamtely 70dB in intensity was employed in the experimental room during all periods of training and testing in order to mask extraneous sounds, including the sounds made by the programming equipment.

On the day following the termination of testing, each subject was interviewed and asked to complete the questionnaires scheduled for the post-test period. These included a series of questions related to attitudes toward the experiment and experimenters, adjustment to the work schedule and other aspects of the study, opinions as to the task difficulties, and any other subjective reactions that the subjects wished to make.

Results

Group Performance Measures

In previous reports of studies employing the MTPB, a major portion of the "Results" section has been dedicated to the measures obtained in the group-performance task--Code Lock Solving. In those investigations, the primary groups of study were the intact, five-person crews. In the present investigation, it will be noted that the primary groups of study are the four experimental groups composed of crewmembers selected from seven different intact crews. Since all of the measures of the Code Lock Solving task are crew-performance measures, it is not possible, in the present study, to present meaningful summaries of the group performances in terms of the experimental groups. Therefore, only the individual-performance measures of the MTPB will be addressed in this report.

Performance Measures of the MTPB

The five individual-performance tasks provide a total of 13 individual-performance measures for each two-hour period of performance. Each of the passive, watchkeeping tasks (Red and Green Warning-Lights, Blinking-Lights, and Probability Monitoring) provide mean normalized speed measures. In addition, a measure of accuracy is obtained for the Probability Monitoring task. Performance on each of the active tasks (Arithmetic Computations and Target Identification) is represented by a measure of the number of problems attempted and a measure of the accuracy of the problems attempted. Each of the measures for the active tasks is provided separately when the tasks are performed with and without the Code Lock Solving task.

Because of the manner in which the tasks of the MTPB are time shared, it is possible for subjects to trade-off the performance of one task in favor of another that they may consider more important. Furthermore, different subjects may judge the relative importance of the tasks differently and, thereby, affect different trade-offs among the several tasks. It is therefore difficult to interpret the results of the 13 separate individual-performance measures (singly or collectively) in terms of the over-all, average, or general effects of various stresses on performance since a decrement on one measure could be offset by an improvement in one or more of the other measures. The interpretation of general results would obviously be facilitated by the use of an index of general performance that combined the results obtained with the 13 separate measures of performance in such a way that the index itself is not affected by the trade-offs such as those described above.

The Mean Percentage of Baseline Performance has been employed as an index of general performance in prior synthetic-work studies (cf. Alluisi, et al., 1967, p. 17). For purposes of the present study, the performances obtained during Monday and Tuesday of the Sleep-loss and Continuous-work phase of the project (i.e., 16 hours of performance immediately preceding the beginning of the continuous work period) are defined as the baseline. The mean performance during this period is computed for each subject with each of the 13 measures of individual performance. Each score for each subject for every two-hour period of performance is then transformed into a percentage of baseline performance, and the 13 percentage-of-baseline scores of a given period are averaged for that subject. The resultant scores, the mean percentages of base-line, are then analyzed and interpreted as an additional individual-performance measure.

The 13 individual-performance measures and the derived Mean Percentage of Baseline Performance obtained for each subject for each two-hour period of performance served as the primary data for the following analyses. For the analyses that call for solely within-group comparisons, the analyses were performed with the original 13 performance measures, and the Mean Percentage of Baseline

Performance. For those analyses calling for between-group comparisons, the analyses were performed on the percentage-of-baseline transformations of the original 13 measures, and the Mean Percentage of Baseline Performance.

Baseline Levels of Performance

Table 3 presents the 13 individual-performance measures of the MTPB and the mean levels of performance (and their standard deviations) during the baseline period for each of the experimental groups in this investigation. For purposes of description, a simple analysis of variance for unequal sample sizes (cf., Winer, 1971, p. 210) was performed for each of the measures to determine if the five groups were performing at significantly different levels during the baseline period. The results of these analyses revealed no significant differences among the groups for any of the measures. Since the remainder of the analyses were performed within the groups or, in the case of between-group comparisons, performed with the percentage-of-baseline measures, the lack of differences between the groups at baseline is of little more than a note that the subjects were performing at approximately the same level. Even the note, however, is subject to the caution that although no differences in mean level of performance were observed, the relative heterogeneity of within-group variance for the active-task measures restricts the observation to a statement that there appears to be no great differences among the mean level of performance although some groups were more homogeneous than other groups.

The Training Phase

For purposes of analyses, the Training and Continuous-Work phases of these studies were combined to provide 64, two-hour performance periods (24 periods of the Training phase and 40 periods of the Continuous-work phase). The 64 periods for each of the five groups were subsequently submitted to a series of Groups-by-

Table 3

Individual Performance Measures of the MTPB With Baseline Means (and Standard Deviations) for BRASP and SPADE Groups

Performance Task (and Measure)	Normal Mid-Cycle	Normal Menstrual	Pill Mid-Cycle	Pill Menstrual	Males
RED Warning Lights (Speed)	9.38 (0.682)	8.88 (0.465)	8.82 (0.826)	8.63 (0.578)	8.95 (1.127)
GREEN Warning Lights (Speed)	8.35 (0.698)	7.64 (0.909)	7.87 (0.808)	7.86 (0.688)	7.93 (1.326)
Blinking Lights (Speed)	6.15 (0.398)	6.05 (0.687)	5.83 (0.599)	5.92 (0.715)	5.31 (0.698)
Probability Monitoring (Accuracy)	75.12 (26.950)	73.92 (31.653)	68.49 (29.095)	71.94 (30.400)	80.20 (22.392)
Probability Monitoring (Speed)	664.53 (88.333)	580.97 (112.354)	642.27 (132.722)	608.00 (109.830)	660.20 (82.679)
Arithmetic W/O Code Lock (Attempted)	99.25 (0.729)	98.59 (0.671)	98.33 (1.464)	98.66 (1.689)	97.15 (2.444)
Arithmetic W/O Code Lock (Accuracy)	96.89 (1.085)	95.58 (1.373)	93.95 (3.620)	93.41 (4.790)	88.54 (16.021)
Arithmetic W/ Code Lock (Attempted)	97.18 (1.805)	97.79 (1.754)	95.84 (3.534)	95.55 (5.604)	93.56 (8.198)
Arithmetic W/ Code Lock (Accuracy)	94.39 (2.349)	94.14 (2.665)	91.72 (5.951)	88.81 (9.610)	85.02 (21.224)
Target ID W/O Code Lock (Attempted)	99.08 (1.606)	99.31 (0.898)	94.22 (10.336)	98.88 (1.840)	95.57 (10.131)
Target ID W/O Code Lock (Accuracy)	94.82 (2.900)	93.86 (1.509)	83.34 (15.507)	84.45 (18.572)	87.45 (15.645)
Target ID W/ Code Lock (Attempted)	99.06 (1.491)	99.49 (0.545)	96.19 (4.102)	98.71 (1.122)	96.04 (4.177)
Target ID W/ Code Lock (Accuracy)	95.88 (2.429)	93.76 (2.301)	86.74 (8.519)	83.18 (15.823)	84.78 (11.297)
Number of Subjects	7	5	8	8	10

Periods preliminary analyses of variance (i.e., 5 X 64) using an unweighted means solution, followed by a set of planned, pair-wise comparisons of the five groups within blocks of 8, two-hour performance periods. Therefore, following each of the overall analyses, the performance periods were subsequently blocked into groups of eight periods to provide for comparisons among the five groups for (1) the first 8 periods of training (i.e., 16 hours), (2) the second 8 periods of training, (3) the last 8 periods of training, and omitting the 16 hours of baseline performance, (4) the first 16 hours of continuous work, (5) the second 16 hours of continuous work, and (6) the third 16 hours of continuous work, and after rest and recovery, (7) the 16 hours of post-recovery performance. Since the object of these analyses was primarily between-group comparisons, the basic data for analyses were the 13 original MTPB measures converted to percentage of baseline measures and the index of general performance, _Mean Percentage of Baseline Performance_.

Table 4 presents a summary of the set of overall Groups-by-Periods analysis of variance by indicating levels of significance obtained for each of the MTPB percentage of baseline measures and the _Mean Percentage of Baseline_ measure. All measures exhibited significant Period effects but only three measures revealed an overall Group effect (_Red Warning Lights_, and the two _Arithmetic_ measures without _Code Lock_). The Period effect was examined in detail, but since each of the measures showing Group effects also exhibited Group-Period interaction effects, the Group effects were not examined _per se_. It should be noted also that except for the _Blinking Lights_ and the two _Probability_ measures, all other measures exhibited significant Group X Period interaction effects.

The set of pair-wise comparisons of the five groups within blocks of 8, two-hour performance periods (i.e., 16 hours) were subsequently computed for the three 8-period blocks that represent the Training Phase of this investigation.

Table 4

Summary of Groups-By-Periods Analysis of Variance of Percentage-of-Baseline MTPB Measures for Training and Continuous-Work Phases

	Source of Variation		
Measure	Groups	Periods	Groups X Periods
RED Warning Lights (Speed)	*	**	**
GREEN Warning Lights (Speed)		**	**
Blinking Lights (Speed)		**	
Probability Monitoring (Accuracy)		**	
Probability Monitoring (Speed)		**	
Arithmetic W/O Code Lock (Attempted)	*	**	**
Arithmetic W/O Code Lock (Accuracy)	*	**	**
Arithmetic W/ Code Lock Attempted)		**	**
Arithmetic W/ Code Lock (Accuracy)		**	**
Target ID W/O Code Lock (Attempted)		**	**
Target ID W/O Code Lock (Accuracy)		**	*
Target ID W/ Code Lock (Attempted)		**	**
Target ID W/ Code Lock (Accuracy)		**	**
Mean Percentage of Baseline Performance		**	**
Degrees of Freedom	4 and 33	63 and 2079	252 and 2079

* P less than 0.05
** P less than 0.01

The results of these pair-wise comparisons for the overall index of general performance, Mean Percentage of Baseline, revealed no differences among the groups within either of the three 8-period blocks of Training. To illustrate the trend of performance during the training period, Figure 2 presents the Mean Percentage of Baseline Performance as a function of the number of hours of training; for purposes of this illustration the experimental groups are presented as Males, Normal Cycling Females, and Pill Females.

The detailed, pair-wise comparisons during the Training phase for the 13 individual MTPB measures revealed differences among the groups only in the first 16 hours of training. Specifically, during the first 16 hours of training significant differences were observed for the Accuracy measure of Arithmetic without Code Lock; the nature of the difference was that the Pill-Menstrual group was significantly lower in percentage of baseline performance for this measure than each of the other four groups. This difference was not observed during the second 16 hours of training. The only other difference observed during the training period involved the Attempted measure of Arithmetic with Code Lock during the first 16 hours of training. Specifically, the Normal-Menstrual group was significantly higher than the other three female groups during the early hours of training. This difference had also disappeared during the second 16 hours of the Training phase. No other differences were observed for any of the measures during the Training phase.

The Sleep-Loss and Continuous-Work Phase

Between-Group Comparisons.--Figure 3 presents the Mean Percentage of Baseline Performance for the five experimental groups over the Sleep-loss and Continuous-work phase of this investigation; it should be noted that the figure is organized by days of the continuous-work week with the abscissa representing time of day. The major divisions of this figure, as noted, are Baseline period, Continuous-work period, Rest and Recovery period, and Post-recovery period.

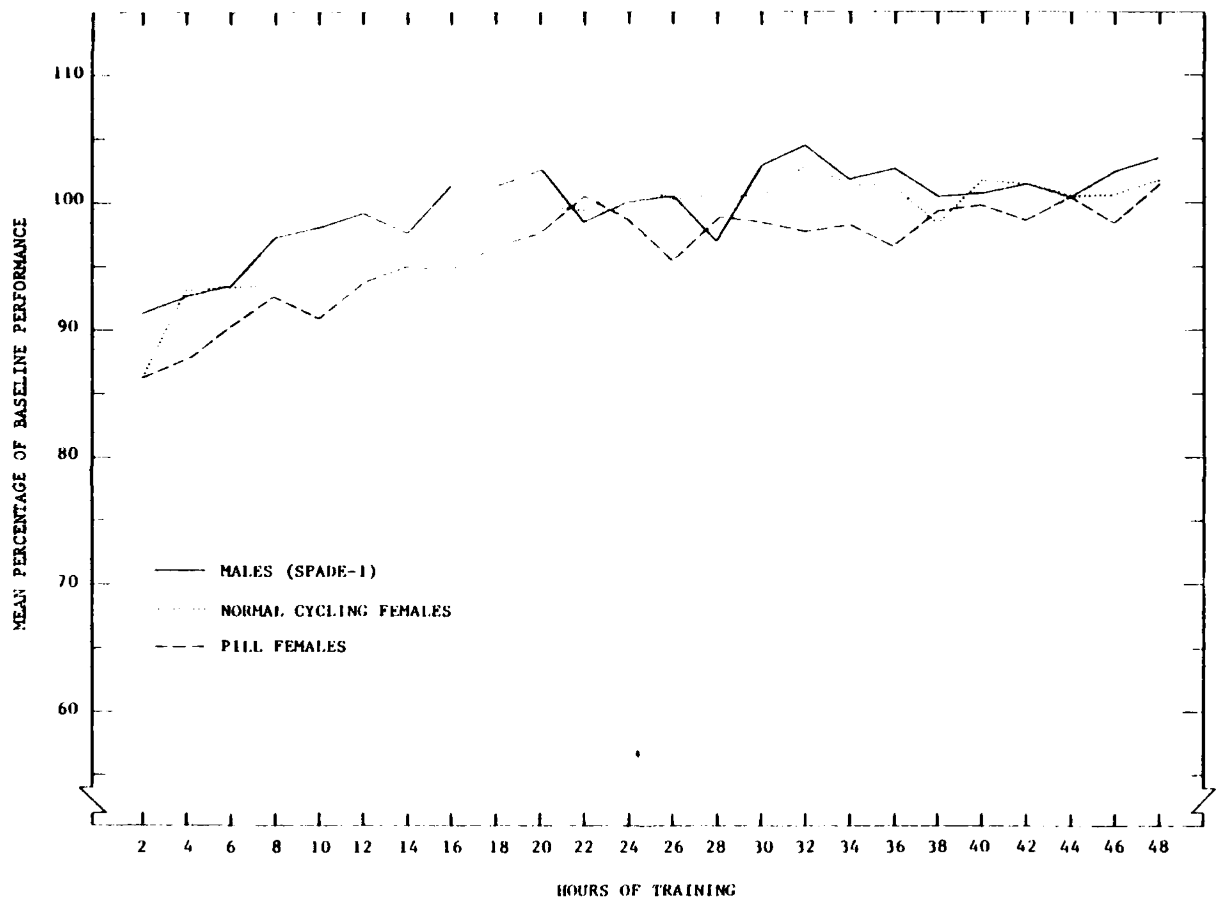

Figure 2: Mean Percentage of Baseline Performance during the Training Phase for Males, Normally Cycling Females, and Pill Females as a function of hours of training.

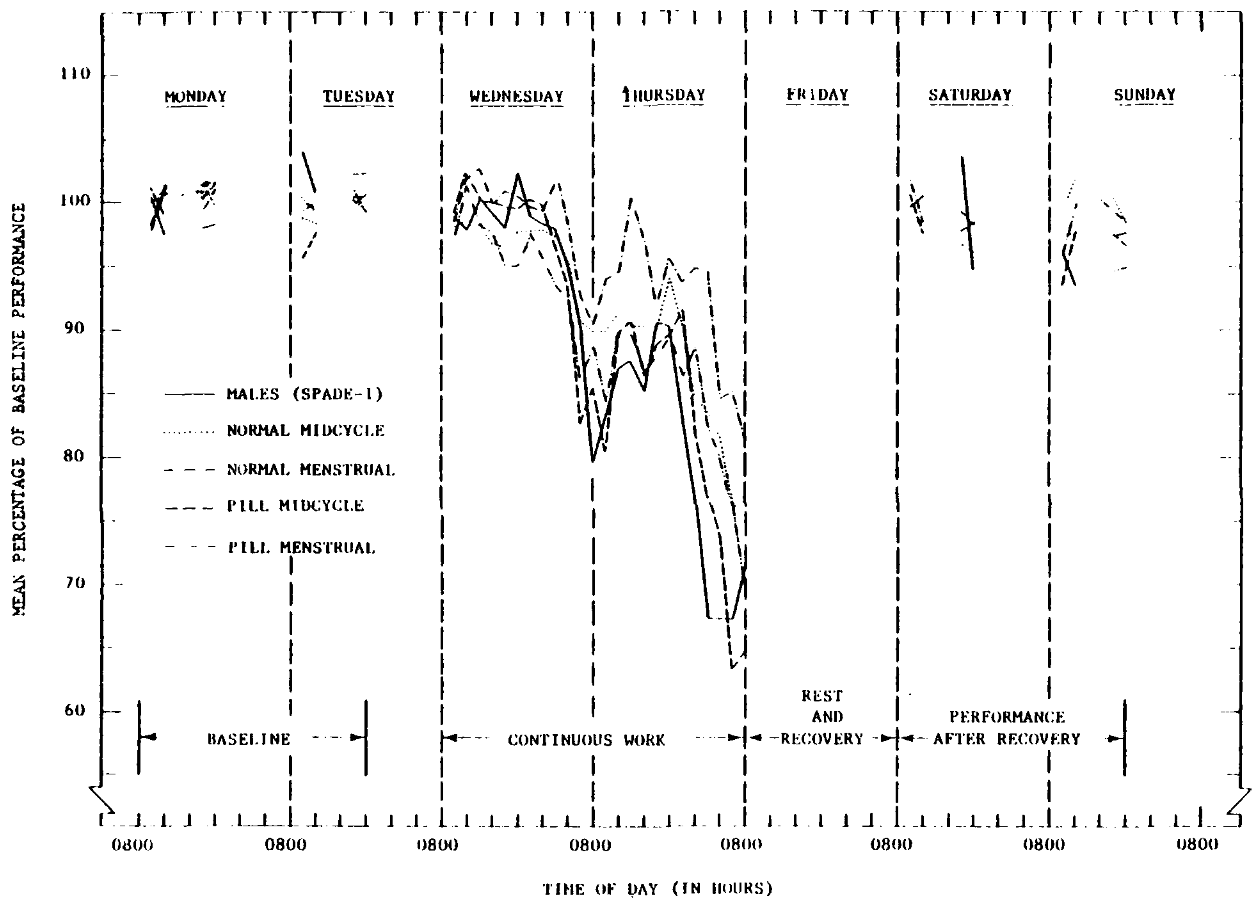

Figure 3: Mean Percentage of Baseline Performance during the Sleep-Loss and Continuous-Work Phase for each of the experimental groups as a function of time of day.

The between-group comparisons of the Baseline period have been treated in a previous section. The between-group comparisons of the Continuous-work period consist of the pair-wise comparisons of the five groups within blocks of 16 hours of performance, noted in the previous section. The pair-wise comparisons of the five groups within the first 16 hours of continuous work revealed no significant differences among the groups on the index of general performance, <u>Mean Percentage of Baseline Performance</u>. Further, analyses of the 13 individual measures revealed that the only significant difference noted during the first 16 hours of sleep loss and continuous work was a significant difference between the Pill Menstrual group and the Male group on the <u>Red Warning Lights</u> measure; the Pill Menstrual group' performance on this measure was significantly higher than that of the male group. No other differences were noted during the first 16 hours of sleep loss and continuous work.

During the second 16 hours of sleep loss and continuous work, there were no differences noted among the groups on the <u>Mean Percentage of Baseline</u> measure. Analyses of the individual measures revealed that the Normal Menstrual group and the Pill Menstrual group performed significantly better on the <u>Red Warning Lights</u> task than did the Male group. Further, the Normal Menstrual group performed significantly better than did the Pill Menstrual group on the <u>Green Warning Lights</u> task. No additional differences among the groups were noted during the second 16 hours of sleep loss and continuous work.

Comparisons of the groups within the third 16 hours of sleep loss and continuous work (33-48 hours) in terms of the index of general performance, <u>Mean Percentage of Baseline</u>, revealed that the performance of the Normal Menstrual group performed significantly higher than both the Pill Mid-Cycle group and the Male group. No additional differences in terms of Mean Percentage of Baseline were noted.

Analyses of the individual measures of the MTPB revealed a number of differences among the groups. On the Red Warning Lights task, the Normal Menstrual and the Pill Menstrual groups performed significantly higher than did the Male group. The Speed measure of the Probability Monitoring task revealed that the Normal Menstrual group performed significantly higher than both the Pill Mid-Cycle and Male groups. On the Attempted measure of Arithmetic without Code Lock all four of the groups performed significantly higher than did the Male group. The Accuracy measure of Arithmetic without Code Lock revealed that the Normal Menstrual group performed significantly better than did both the Pill Menstrual and the Male groups; in addition, Normal Mid-Cycle group performed significantly higher than the Male group on the Accuracy measure of Arithmetic without Code Lock. The Normal Menstrual group also performed significantly better than the Pill Mid-Cycle and the Male groups on the Attempted measure of Arithmetic with Code Lock. The comparisons of the groups for the Target Identification without Code Lock, Attempted measure revealed that the Normal Mid-Cycle group performed better than both the Pill Mid-Cycle and the Male groups. On the Attempted measure of Target Identification with Code Lock, both the Normal Mid-Cycle and the Normal Menstrual groups performed better than both the Pill Mid-Cycle and the Male groups; the Pill Menstrual group performed significantly better than the Pill Mid-Cycle group on the same task. Finally, the Normal Menstrual group performed significantly better than both the Pill Mid-Cycle and the Male groups on the Accuracy measure of Target Identification with Code Lock; in addition, the Pill Menstrual group performed better than the Male group on this measure also.

In terms of the magnitude of decrement for the five experimental groups, a review of Figure 3 reveals that the Normal Menstrual group experienced a maximum decrement in Mean Percentage of Baseline Performance of approximately 18.1%

of baseline. The maximum decrement observed for the Pill Mid-Cycle group was approximately 36.7% of baseline, and for the Male group, maximum decrement of performance was 33.9%. Intermediately, the maximum decrement for the Normal Mid-Cycle group was 24.3% of baseline, and for the Pill Menstrual, the maximum decrement was 30.4% of baseline.

In summary, the between-group comparisons of the sleep-loss and continuous-work period reveal that for the first 32 hours, the groups performed at essentially the same levels with respect to percentage of baseline performances. During the final 16 hours of sleep loss, however, the decrements experienced by the Pill Mid-Cycle and Male groups resulted in significant differences between these two groups and the Normal Menstrual group on the overall index of general performance. Analyses of the individual measures revealed a number of differences between these groups that together resulted in the difference in the overall index; in addition, a number of individual-measure differences were noted between the other groups and the Pill Mid-Cycle and Male groups.

Between-group comparisons of the post-recovery performance reveal no significant differences among the groups with respect to the overall index of general performance. Comparisons with the individual measures indicated that during the post-recovery period, the Pill Menstrual group performed significantly better on the Red Warning Lights measure than did the Male group--a difference that existed throughout the continuous-work period also. In addition, the Normal Menstrual group continued to perform better than the Pill Mid-Cycle group on the Speed measure of Probability Monitoring. Generally, however, the groups were performing at relatively the same levels following the 24 hours of rest and recovery.

Within-Group Comparisons.--The analysis of the processes involved in the Continuous-work phase of this investigation can best be achieved by detailed analyses within each of the five experimental groups. Accordingly, an analysis of variance was performed on each of the 13 individual-performance measures of the MTPB and the Mean Percentage of Baseline Performance; the analysis was a Periods-by-Subjects analysis with comparisons of Baseline performance levels with (a) average performance during 48 hours of continuous work, (b) average performance during first 16 hours of continuous work, (c) average performance during second 16 hours of continuous work, (d) average performance during third 16 hours of continuous work, and (e) average performance during the post-recovery period. It should be noted that with the exception of Mean Percentage of Baseline Performance, these analyses were performed on the untransformed individual performance measures. Since all measures for all groups resulted in a significant Period effect in the overall analysis, the comparisons only are addressed in the following summaries.

Table 5 presents the obtained F-values comparing performance during the baseline period with the average performance during the full 48 hours of continuous work and sleep loss for each group with each measure of performance. It will be noted that with the exception of the Normal Menstrual group, all groups exhibited significantly lower levels of performance over the sleep-loss and continuous-work period than during the baseline period. For the Normal Menstrual group, significantly lower levels during sleep loss were observed on 8 of the 13 individual measures and Mean Percentage of Baseline Performance.

Table 6 presents the obtained F-values that are similar to the previous table except that it focuses on the first 16 hours of sleep loss and continuous work. Two of the groups (Normal Mid Cycle and Pill Menstrual) exhibited significant (P less than .05) decrements in Mean Percentage of Baseline Performance during this period of sleep loss while all groups showed decrements in some individual measures.

Table 5

Summary of Analyses of Individual Tasks Within Groups--Comparing Baseline Performance With Performance During 48 hours of Continuous Work (Entries are Obtained F-Values)#

Performance Task (and Measure)	Normal Mid-Cycle	Normal Menstrual	Pill Mid-Cycle	Pill Menstrual	Males
RED Warning Lights (Speed)	52.575**	4.041*	36.233**	5.185*	215.780**
GREEN Warning Lights (Speed)	20.330**	------	21.674**	33.311**	80.483**
Blinking Lights (Speed)	32.822**	19.611**	47.727**	56.311**	77.504**
Probability Monitoring (Accuracy)	88.815**	22.248**	77.397**	104.647**	175.505**
Probability Monitoring (Speed)	57.682**	------	91.255**	70.668**	198.224**
Arithmetic W/O Code Lock (Attempted)	23.226**	------	37.285**	20.771**	62.798**
Arithmetic W/O Code Lock (Accuracy)	38.353**	1.908	54.686**	50.677**	80.173**
Arithmetic W/ Code Lock (Attempted)	5.469*	------	85.189**	29.997**	98.540**
Arithmetic W/ Code Lock (Accuracy)	34.767**	2.050	122.884**	40.182**	112.718**
Target ID W/O Code Lock (Attempted)	15.928**	12.683**	35.473**	34.096**	76.630**
Target ID W/O Code Lock (Accuracy)	49.702**	15.314**	57.597**	60.033**	83.245**
Target ID W/ Code Lock (Attempted)	29.818**	9.582**	95.308**	44.897**	105.398**
Target ID W/ Code Lock (Accuracy)	103.358**	16.795**	145.666**	98.327**	137.524**
Mean Percentage of Baseline Performance	121.964**	16.433**	186.530**	137.563**	209.719**
Degrees of Freedom	1 and 378	1 and 252	1 and 441	1 and 441	1 and 567

* P less than 0.05
** P less than 0.01
\# F-Values of less than 1.00 have been omitted

Table 6

Summary of Analyses of Individual Tasks Within Groups--Comparing Baseline Performance With Performance During First 16 Hours of Continuous Work (Entries are Obtained F-Values)#

Performance Task (and Measure)	Normal Mid-Cycle	Normal Menstrual	Pill Mid-Cycle	Pill Menstrual	Males
RED Warning Lights (Speed)	1.281	-----	-----	2.693	53.431**
GREEN Warning Lights (Speed)	-----	5.642*	-----	-----	11.172**
Blinking Lights (Speed)	-----	7.718**	4.988*	2.678	1.768
Probability Monitoring (Accuracy)	5.489*	-----	-----	10.381**	1.996
Probability Monitoring (Speed)	5.377*	-----	6.701**	-----	-----
Arithmetic W/O Code Lock (Attempted)	2.361	-----	-----	-----	1.867
Arithmetic W/O Code Lock (Accuracy)	4.499*	-----	-----	3.377	3.024
Arithmetic W/ Code Lock (Attempted)	-----	-----	1.732	-----	-----
Arithmetic W/ Code Lock (Accuracy)	-----	-----	1.190	-----	-----
Target ID W/O Code Lock (Attempted)	-----	-----	3.487	1.527	1.212
Target ID W/O Code Lock (Accuracy)	1.651	-----	2.243	3.060	-----
Target ID W/ Code Lock (Attempted)	-----	-----	-----	-----	-----
Target ID W/ Code Lock (Accuracy)	9.265**	1.249	-----	9.268**	-----
Mean Percentage of Baseline Performance	4.184*	-----	-----	6.516*	-----
Degrees of Freedom	1 and 378	1 and 252	1 and 441	1 and 441	1 and 567

*P less than 0.05
**P less than 0.01
#F-Values of less than 1.00 have been omitted

A summary of the comparisons of performances during the second 16 hours of sleep loss and continuous work with performances during the baseline period is presented in Table 7. All groups exhibited significant decrements in overall performance as assessed by Mean Percentage of Baseline Performance. Three of the groups (Pill Mid-Cycle, Pill Menstrual, and Males) exhibited significant decrements on all measures of performance, while the Normal Mid-Cycle group showed decrements on 12 of the 13 individual measures. The Normal Menstrual group had decrements on only 5 of the 13 individual measures.

The comparisons for the third 16 hours of sleep loss and continuous work and sleep loss, presented in Table 8, reveals that, again, all groups showed significant decrements in overall performance, with all groups except the Normal Menstrual group exhibiting significant decrements (P less than .01) on all individual measures. In the final third of sleep loss and continuous work, the Normal Menstrual group exhibited significant decrements on only 10 of the 13 individual measures.

To permit assessment of the degree to which the groups recovered to baseline levels of performance following 24 hours of rest and recovery, Table 9 presents a summary of the comparisons between baseline levels of performances and performances during the post-recovery periods of performance. Three groups (Pill Mid-Cycle, Pill Menstrual, and Males) remained significantly lower than the baseline performance levels as indicated by Mean Percentage of Baseline Performance. All groups exhibited some measures that were significantly lower than baseline levels. It is of interest to note that of the 18 individual measures that were significantly different from baseline levels, 11 were measures of watchkeeping performance and the remaining 7 measures involved accuracy on the active tasks.

Individual differences.--The data presented above have shown the average effects of sleep loss and continuous work on performance. Previous studies

Table 7

Summary of Analyses of Individual Tasks Within Groups--Comparing Baseline Performance With Performance During Second 16 Hours of Continuous Work (Entries are Obtained F-Values)#

Performance Task (and Measure)	Normal Mid-Cycle	Normal Menstrual	Pill Mid-Cycle	Pill Menstrual	Males
RED Warning Lights (Speed)	62.346**	1.638	40.562**	6.509*	158.311**
GREEN Warning Lights (Speed)	17.687**	-----	20.467**	52.433**	106.962**
Blinking Lights (Speed)	16.454**	3.039	31.672**	39.097**	46.840**
Probability Monitoring (Accuracy)	72.149**	18.553**	84.285**	91.522**	112.231**
Probability Monitoring (Speed)	38.725**	-----	54.410**	16.704**	150.839**
Arithmetic W/O Code Lock (Attempted)	12.155**	-----	24.760**	10.776**	15.325**
Arithmetic W/O Code Lock (Accuracy)	18.834**	1.235	23.332**	32.937**	19.642**
Arithmetic W/ Code Lock (Attempted)	1.411	-----	26.829**	10.017**	44.841**
Arithmetic W/ Code Lock (Accuracy)	5.367*	-----	54.725**	28.851**	54.698**
Target ID W/O Code Lock (Attempted)	4.099*	6.462*	20.927**	18.627**	45.594**
Target ID W/O Code Lock (Accuracy)	17.188**	12.578**	59.075**	40.835**	61.698**
Target ID W/ Code Lock (Attempted)	13.947**	5.229*	66.937**	35.357**	60.789**
Target ID W/ Code Lock (Accuracy)	45.577**	8.600**	112.409**	75.764**	76.090**
Mean Percentage of Baseline Performance	72.458**	8.262**	147.509**	104.126**	138.278**
Degrees of Freedom	1 and 378	1 and 252	1 and 441	1 and 441	1 and 567

*P less than 0.05
**P less than 0.01
#F-Values of less than 1.00 have been omitted

Table 8

Summary of Analyses of Individual Tasks Within Groups--Comparing Baseline Performance With Performance During Third 16 Hours of Continuous Work (Entries are Obtained F-Values)#

Performance Task (and Measure)	Normal Mid-Cycle	Normal Menstrual	Pill Mid-Cycle	Pill Menstrual	Males
RED Warning Lights (Speed)	76.047**	13.345**	66.049**	21.784**	258.883**
GREEN Warning Lights (Speed)	54.738**	5.528*	54.116**	41.551**	68.729**
Blinking Lights (Speed)	94.107**	39.809**	82.101**	110.080**	179.313**
Probability Monitoring (Accuracy)	150.003**	51.877**	134.364**	150.527**	417.951**
Probability Monitoring (Speed)	101.240**	2.228	180.487**	34.938**	453.460**
Arithmetic W/O Code Lock (Attempted)	45.996**	-----	106.256**	50.392**	199.659**
Arithmetic W/O Code Lock (Accuracy)	75.842**	6.608*	163.434**	97.233**	248.430**
Arithmetic W/ Code Lock (Attempted)	23.515**	-----	259.616**	87.860**	303.696**
Arithmetic W/ Code Lock (Accuracy)	138.247**	11.495**	348.371**	118.858**	329.590**
Target ID W/O Code Lock (Attempted)	57.542**	39.506**	141.176**	76.588**	249.359**
Target ID W/O Code Lock (Accuracy)	140.136**	44.136**	153.797**	117.492**	220.528**
Target ID W/ Code Lock (Attempted)	85.850**	26.022**	269.159**	100.883**	310.266**
Target ID W/ Code Lock (Accuracy)	228.247**	38.862**	355.025**	157.266**	371.116**
Mean Percentage of Baseline Performance	272.043**	54.701**	462.092**	255.121**	373.009**
Degrees of Freedom	1 and 378	1 and 252	1 and 441	1 and 441	1 and 567

*P less than 0.05
**P less than 0.01
#F-Values of less than 1.00 have been omitted

Table 9

Summary of Analyses of Individual Tasks Within Groups--Comparing Baseline Performance With Performance During 16 Hours Following 24 Hours of Rest and Recovery (Entries are Obtained F-Values)#

Performance Task (and Measure)	Normal Mid-Cycle	Normal Menstrual	Pill Mid-Cycle	Pill Menstrual	Males
RED Warning Lights (Speed)	-----	-----	-----	14.151**	24.898**
GREEN Warning Lights (Speed)	-----	2.196	-----	-----	2.079
Blinking Lights (Speed)	8.064**	8.333**	3.842	5.189*	6.697**
Probability Monitoring (Accuracy)	-----	7.846**	35.157**	28.353**	-----
Probability Monitoring (Speed)	3.004	-----	49.830**	2.301	4.705*
Arithmetic W/O Code Lock (Attempted)	-----	-----	-----	-----	1.001
Arithmetic W/O Code Lock (Accuracy)	4.878*	-----	4.968*	7.186**	13.590**
Arithmetic W/ Code Lock (Attempted)	-----	-----	-----	-----	2.120
Arithmetic W/ Code Lock (Accuracy)	2.417	-----	1.711	3.634	13.200**
Target ID W/O Code Lock (Attempted)	-----	-----	1.011	-----	-----
Target ID W/O Code Lock (Accuracy)	-----	-----	2.259	9.542**	9.936**
Target ID W/ Code Lock (Attempted)	-----	-----	-----	-----	-----
Target ID W/ Code Lock (Accuracy)	2.285	-----	1.117	2.631	3.615
Mean Percentage of Baseline Performance	-----	-----	6.408*	7.933**	3.930*
Degrees of Freedom	1 and 378	1 and 252	1 and 441	1 and 441	1 and 567

*P less than 0.05
**P less than 0.01
#F-Values of less than 1.00 have been omitted

using the MTPB have revealed a wide range of individual differences in responses to various stressors. To assess the individual responses to the sleep loss and continuous work in the present investigation, a series of correlation and regression analyses were performed involving the individual's measures of performance during the continuous-work period and the corresponding "number of hours since beginning continuous work." Specifically, the individual's performances as indicated by the 13 individual measures (expressed as a percentage of baseline) and Mean Percentage of Baseline Performance were correlated with the corresponding number of hours of continuous work to obtain (a) Pearson Product Moment Correlation coefficients (r) relating performance and time on duty, (b) the corresponding coefficients of determination (r^2), and (c) the linear slope constant of the least-squares regression line that permits prediction of the criteria from the number of hours of continuous duty. The coefficients of determination can be employed to assess the proportion of variation in the individual's performance that can be accounted for by the time on duty. The linear slope constants can be employed (a) to assess the steepness of the performance curve over time of continuous work (at least, to the extent to which the decrement is linear with time), and (b) as an expression of the percentage of baseline decrement associated with each hour of continuous work.

Tables 10 and 11 present the results of these analyses for each of the subjects in each of the experimental groups. In addition, data were computed for an "average subject" for each group by use of arithmetic means of the subjects' performances on each of the performance measures; the average subject(AvS) was subsequently treated as any other subject in these analyses. Because the statistical significance of the correlation is based on the coefficient of determination, and not on the absolute size of the linear slope constant, those figures that represent values which are significantly different from zero are indicated on both tables. In some cases, of course, lesser slope constants are statistically significant, while greater ones are not.

Table 10

Coefficients of Determination (100 r^2) Based on Correlations With Number of Hours of Continuous Work

Subject Number	Blinking Lights (Speed)	RED Warning Lights (Speed)	GREEN Warning Lights (Speed)	Probability (Accuracy)	Probability (Speed)	Arithmetic W/O CL (Attempted)	Arithmetic W/O CL (Accuracy)	Arithmetic W/ CL (Attempted)	Arithmetic W/ CL (Accuracy)	Target ID W/O CL (Attempted)	Target ID W/O CL (Accuracy)	Target ID W/ CL (Attempted)	Target ID W/ CL (Accuracy)	Mean Percentage of Baseline Performance
Normal Mid-Cycle														
1-1	5.62	36.99**	39.23**	43.52**	0.31	37.24**	48.95**	34.32**	25.71*	29.29**	32.60**	31.04**	27.79**	58.41**
1-2	4.23	3.08	8.23	35.43**	42.82**	7.54	12.38	40.43**	26.11*	10.00	3.36	11.53	8.07	5.22
1-3	33.87**	28.37**	35.58**	28.81**	29.05**	23.96*	21.70*	20.18*	20.54*	5.95	17.69*	14.64	61.77**	62.96**
1-4	51.53**	28.05**	40.94**	13.28	75.57**	36.11**	26.13*	24.89*	32.63**	38.99**	64.80**	47.11**	39.34**	64.94**
1-5	56.97**	11.46	7.95	38.05**	70.19**	3.31	12.31	59.83**	55.14**	14.78	15.69	17.80*	19.36*	82.41**
1-6	42.46**	35.80**	33.53**	40.23**	63.39**	6.44	3.94	45.70**	49.74**	23.78*	36.99**	9.61	22.07*	55.71**
1-7	54.12**	10.61	6.88	65.96**	40.67**	20.79*	19.96*	39.33**	37.30**	42.56**	44.69**	48.32**	48.12**	61.69**
AvS	70.96**	60.55**	62.25**	67.00**	71.27**	32.27**	49.64**	52.78**	53.12**	51.31**	68.13**	58.14**	52.75**	80.09**
Normal Menstrual														
2-1	14.30	36.36**	28.86**	72.55**	80.14**	11.95	8.09	14.70	21.84*	34.40**	49.07**	17.35	42.67**	65.64**
2-2	7.12	0.47	8.31	11.89	57.35**	8.19	21.22*	4.05	11.49	5.61	9.88	0.00	12.98	0.60
2-3	2.79	0.40	2.48	19.09*	7.33	7.49	17.51*	0.35	1.57	2.39	0.19	0.79	0.04	0.77
2-4	13.33	0.00	31.79**	3.11	73.48**	14.23	16.61*	29.87**	29.28**	13.83	22.72*	32.44**	3.32	34.30**
2-5	18.39*	55.12**	42.45**	78.67**	14.35	2.11	0.49	24.66*	22.60*	31.39**	36.16**	35.31**	28.74**	59.23**
AvS	24.81*	34.66**	40.97**	50.38**	26.77**	15.51	33.66**	35.81**	31.66**	46.08**	58.80**	43.95**	46.35**	64.38**

*P less than 0.05
**P less than 0.01

Table 10 (Continued)

Coefficients of Determination (100 r^2) Based on Correlations With Number of Hours of Continuous Work

Subject Number	Blinking Lights (Speed)	RED Warning Lights (Speed)	GREEN Warning Lights (Speed)	Probability (Accuracy)	Probability (Speed)	Arithmetic W/O CL (Attempted)	Arithmetic W/O CL (Accuracy)	Arithmetic W/ CL (Attempted)	Arithmetic W/ CL (Accuracy)	Target ID W/O CL (Attempted)	Target ID W/O CL (Accuracy)	Target ID W/ CL (Attempted)	Target ID W/ CL (Accuracy)	Main Percentage of Baseline Performance
Pill Mid-Cycle														
3-1	42.92**	19.80*	37.10**	63.98**	56.94**	28.41**	44.86**	8.25	51.98**	48.52**	53.32**	51.72**	51.21**	63.16**
3-2	49.88**	35.08**	27.03**	46.70**	72.55**	12.73	21.64*	29.70**	16.55*	17.06*	50.97**	32.83**	50.97**	69.94**
3-3	3.51	14.62	35.85**	11.34	88.33**	35.77**	51.04**	60.49**	71.84**	27.13**	28.19**	19.71*	21.07*	55.89**
3-4	13.94	15.36	18.84*	48.62**	82.99**	7.68	4.91	46.66**	46.53**	50.26**	62.39**	47.31**	55.92**	70.79**
3-5	7.74	25.77**	0.72	0.16	69.69**	13.88	28.50**	36.09**	36.33**	64.38**	56.64**	50.74**	54.46**	60.68**
3-6	37.94**	15.03	19.28*	64.34**	47.36**	54.35**	54.65**	58.32**	56.03**	52.87**	34.67**	34.97**	38.81**	66.22**
3-7	28.55**	6.05	6.43	28.35**	21.55*	24.70*	35.30**	43.39**	48.62**	37.01**	53.60**	46.65**	52.56**	56.81**
3-8	3.68	4.07	9.76	8.90	26.63**	16.97*	16.13*	46.93**	44.20**	3.17	0.10	18.51*	39.28**	21.86*
AvS	64.21**	35.18**	54.03**	54.61**	69.09**	51.95**	61.63**	57.60**	65.40**	62.65**	65.89**	52.71**	60.22**	74.86**
Pill Menstrual														
4-1	11.65	37.52**	32.80**	69.64**	6.28	52.67**	52.45**	62.93**	61.37**	29.94**	46.62**	15.18	5.56	65.89**
4-2	39.07**	16.79*	5.45	24.29*	67.99**	5.21	6.00	11.54	0.69	21.53*	41.76**	29.68**	38.71**	59.43**
4-3	39.01**	1.39	5.21	3.90	72.40**	9.78	1.60	0.17	0.67	6.56	29.96**	0.00	41.04**	9.63
4-4	56.27**	23.96*	10.95	33.11**	77.14**	32.13**	50.92**	43.50**	57.06**	2.39	18.07*	13.93	21.33*	67.19**
4-5	26.18*	24.08*	35.45**	62.68**	38.15**	78.70**	78.19**	78.35**	79.89**	72.98**	79.33**	66.53**	61.49**	91.89**
4-6	16.53*	0.53	0.00	0.03	28.16**	5.51	2.17	28.09**	35.06**	6.33	19.38*	16.23	42.91**	28.11**
4-7	40.87**	21.83*	36.98**	0.29	13.24	32.26**	46.04**	41.34**	32.49**	31.71**	0.52	48.32**	24.00*	39.52**
4-8	7.58	23.08*	4.33	65.47**	35.48**	26.44*	23.17*	30.57**	43.34**	10.39	6.78	4.05	21.35*	48.43**
AvS	63.62**	63.83**	34.00**	65.19**	41.40**	73.58**	79.64**	55.54**	78.32**	56.70**	63.91**	55.41**	57.55**	79.95**

*$\underline{P}$ less than 0.05
**$\underline{P}$ less than 0.01

Table 10 (Continued)

Coefficients of Determination (100 r^2) Based on Correlations With Number of Hours of Continuous Work

BRASP Group Subject Number	Blinking Lights (Speed)	RED Warning Lights (Speed)	GREEN Warning Lights (Speed)	Probability (Accuracy)	Probability (Speed)	Arithmetic W/O CL (Attempted)	Arithmetic W/O CL (Accuracy)	Arithmetic W/ CL (Attempted)	Arithmetic W/ CL (Accuracy)	Target ID W/O CL (Attempted)	Target ID W/O CL (Accuracy)	Target ID W/ CL (Attempted)	Target ID W/ CL (Accuracy)	Mean Percentage of Baseline Perf.
Males														
5-1	39.65**	31.38**	2.55	50.62**	54.48**	46.91**	61.31**	49.28**	50.10**	27.90**	29.88**	45.31**	59.75**	63.00**
5-2	16.40*	23.47*	2.14	63.89**	62.38**	30.01**	21.14*	35.39**	28.54**	11.25	19.48*	25.80*	29.76**	51.29**
5-3	30.07**	6.79	0.92	5.65	15.66	32.95**	41.86**	49.24**	53.80**	34.09**	29.52**	46.50**	47.49**	68.51**
5-4	33.05**	16.97*	5.49	33.38**	39.83**	15.84	20.97*	37.15**	36.46**	24.86*	23.52*	31.91**	35.62**	39.01**
5-5	37.94**	5.24	19.12*	58.77**	48.26**	34.63**	66.04**	28.44**	36.25**	20.32*	35.16**	15.09	35.24**	50.03**
5-6	19.08*	4.15	18.87*	26.30*	26.41*	24.98*	23.94*	31.95**	36.18**	17.39*	30.88**	21.29*	46.77**	45.76**
5-7	30.01**	7.29	0.37	30.93**	40.71**	16.53*	29.14**	10.96	12.20	42.07**	39.45**	33.26**	24.70*	44.17**
5-8	8.53	1.79	2.05	33.51**	32.75**	28.99**	34.12**	50.02**	44.28**	19.50*	48.41**	19.94*	41.99**	49.50**
5-9	12.93	31.53**	10.74	13.90	26.43*	31.31**	28.10**	53.01**	51.88**	43.10**	37.16**	49.14**	59.57**	61.88**
5-10	34.29**	18.78*	0.16	66.58**	67.89**	1.06	6.88	39.53**	37.70**	43.62**	40.99**	27.57**	33.34**	58.53**
AvS	61.97**	38.06**	18.03*	72.90**	73.79**	63.07**	69.52**	67.90**	67.33**	65.06**	69.19**	68.60**	76.58**	78.87**

*P less than 0.05
**P less than 0.01

Table 11

Linear Slope Constants for Predictions of Task Percentage Baseline from Number of Hours of Continuous Work

Subject Number	Blinking Lights (Speed)	RED Warning Lights (Speed)	GREEN Warning Lights (Speed)	Probability (Accuracy)	Probability (Speed)	Arithmetic W/O CL (Attempted)	Arithmetic W/O CL (Accuracy)	Arithmetic W/ CL (Attempted)	Arithmetic W/ CL (Accuracy)	Target ID W/O CL (Attempted)	Target ID W/O CL (Accuracy)	Target ID W/ CL (Attempted)	Target ID W/ CL (Accuracy)	Mean Percentage of Baseline Perf.
Normal Mid-Cycle														
1-1	-0.13	-0.29**	-0.47**	-1.27**	0.04	-0.11**	-0.28**	-0.41**	-0.48*	-0.14**	-0.37**	-0.18**	-0.44**	-0.35**
1-2	0.11	-0.09	-0.22	-0.51**	1.09**	-0.02	-0.07	-0.30**	-0.30*	-0.02	-0.05	-0.04	-0.09	-0.04
1-3	-0.51**	-0.38**	-0.63**	-0.70**	-0.36**	-0.06*	-0.19*	-0.14*	-0.19*	-0.03	-0.18*	-0.07	-0.54**	-0.31**
1-4	-0.98**	-0.33**	-0.60**	-1.50	-1.49**	-0.16**	-0.20*	-0.51*	-0.58**	-0.54**	-1.25**	-0.79**	-0.90**	-0.76**
1-5	-0.48**	-0.24	-0.24	-1.21**	-1.24**	-0.03	-0.11	-0.53**	-0.69**	-0.04	-0.23	-0.12*	-0.41*	-0.43**
1-6	-0.39**	-0.37**	-0.57**	-1.24**	-0.88**	0.09	-0.09	-0.33**	-0.40**	-0.11*	-0.45**	-0.15	-0.44*	-0.40**
1-7	-0.90**	-0.20	-0.33	-1.68**	-0.59**	-0.31	-0.37*	-0.71**	-0.71**	-1.13**	-1.15**	-1.20**	-1.22**	-0.81**
AvS	-0.47**	-0.27**	-0.44**	-1.16**	-0.49**	-0.09**	-0.16**	-0.42**	-0.48**	-0.28*	-0.53**	-0.36**	-0.58**	-0.44**
Normal Menstrual														
2-1	-0.47	-0.43**	-0.55**	-1.94**	-1.11**	-0.04	-0.09	-0.20	-0.39*	-0.83**	-1.23**	-0.35*	-0.93**	-0.66**
2-2	-0.12	0.06	-0.21	-0.18	1.09**	-0.04	-0.14*	-0.06	-0.14	-0.03	-0.19	0.00	-0.23	-0.02
2-3	0.09	0.03	-0.11	-0.36*	0.25	-0.05	-0.14*	-0.01	-0.04	0.03	-0.02	-0.01	0.01	-0.02
2-4	-0.28*	-0.00	-0.57**	-0.78	-1.01**	-0.10	-0.12*	-0.28**	-0.31**	-0.29	-0.51*	-0.17**	-0.12	-0.35**
2-5	-0.36*	-0.66**	-0.52**	-2.28**	-0.34	0.03	0.02	-0.15*	-0.17*	-0.78**	-0.94**	-0.69**	-0.73**	-0.58**
AvS	-0.23*	-0.20**	-0.39**	-1.11**	-0.23**	-0.04	-0.09**	-0.14**	-0.21**	-0.38**	-0.57**	-0.24**	-0.40**	-0.33**

*P less than 0.05
**P less than 0.01

Table 11 (Continued)

Linear Slope Constants for Predictions of Task Percentage Baseline from Number of Hours of Continuous Work

Subject Number	Blinking Lights (Speed)	RED Warning Lights (Speed)	GREEN Warning Lights (Speed)	Probability (Accuracy)	Probability (Speed)	Arithmetic W/O CL (Attempted)	Arithmetic W/O CL (Accuracy)	Arithmetic W/ CL (Attempted)	Arithmetic W/ CL (Accuracy)	Target ID W/O CL (Attempted)	Target ID W/O CL (Accuracy)	Target ID W/ CL (Attempted)	Target ID W/ CL (Accuracy)	Mean Percentage of Baseline Performance
Pill Mid-Cycle														
3-1	-0.66**	-0.22*	-0.72**	-1.79**	-0.73**	-0.36**	-0.79**	-0.45	-0.93**	-1.28**	-1.23**	-1.14**	-1.34**	-0.89**
3-2	-0.56**	-0.30**	-0.55**	-0.58**	-0.49**	-0.04	-0.15*	-0.10**	-0.18*	-0.06*	-0.62**	-0.10**	-0.60**	-0.33**
3-3	-0.16	-0.38	-0.81**	-1.01	-0.98**	-0.65**	-1.04**	-1.39**	-1.79**	-1.36**	-1.64**	-0.82*	-0.92*	-1.00**
3-4	-0.16	-0.32	-0.29*	-1.57**	-0.93**	-0.04	-0.06	-0.81**	-0.83**	-0.35**	-0.58**	-0.94**	-1.09**	-0.61**
3-5	-0.18	-0.44*	-0.07	-0.17	-1.05**	-0.08	-0.16**	-0.84**	-0.91**	-1.34**	-1.44**	-1.32**	-1.57**	-0.74**
3-6	-0.38**	-0.29	-0.41*	-1.71**	-0.70**	-0.70**	-0.81**	-1.38**	-1.60**	-1.11**	-1.41**	-1.00**	-1.53**	-1.00**
3-7	-0.44**	-0.23	-0.22	-0.82**	0.46*	-0.10*	-0.34**	-0.57**	-0.90**	-1.14**	-1.46**	-1.04**	-1.15**	-0.61**
3-8	-0.11	-0.18	-0.35	-1.50	0.41**	-0.12*	-0.19*	-0.26**	-0.51**	-0.10	-0.04	-0.20*	-0.59	-0.29*
AvS	-0.33**	-0.30**	-0.43**	-1.14**	-0.50**	-0.26**	-0.44**	-0.73**	-0.96**	-0.84**	-1.05**	-0.82**	-1.10**	-0.68**
Pill Menstrual														
4-1	-0.99	-0.35**	-0.57**	-1.24**	-0.14	-0.38**	-0.60**	-0.72**	-0.91**	-0.32**	-0.65**	-0.23	-0.37	-0.57**
4-2	-0.51**	-0.23*	-0.36	-0.49*	-0.64**	-0.02	-0.06	0.48	-0.02	-0.07*	-0.34**	-0.16**	-0.47**	-0.22**
4-3	-0.34**	0.06	-0.16	-0.04	2.05**	-0.02	-0.03	0.06	-0.02	-0.01	-0.28**	0.00	-0.36**	0.07
4-4	-0.71**	-0.57*	-0.28	-1.31**	-1.17**	-0.10**	-0.32**	-0.24**	-0.53**	0.21	-0.31*	-0.18	-0.43*	-0.46**
4-5	-0.59*	-0.41*	-0.77**	-2.69**	-0.58**	-1.13**	-1.29**	-1.93**	-2.48**	-1.58**	-1.93**	-1.35**	-1.53**	-1.40**
4-6	-0.36*	0.04	0.00	-0.04	-0.42**	0.03	-0.04	-0.23**	-0.35**	-0.05	-0.31*	-0.19*	-0.62**	-0.20**
4-7	-0.49**	-0.32*	-0.60**	0.16	-0.46	-0.40**	-0.64**	-0.80**	-1.09**	-0.52**	-0.14	-1.05**	-0.88*	-0.56**
4-8	-0.16	-0.23*	-0.25	-1.61**	-0.43**	-0.20*	-0.29*	-0.82**	-1.20**	-0.18	-0.24	-0.17	-0.49*	-0.48**
AvS	-0.52**	-0.25**	-0.37**	-0.91**	-0.22**	-0.28**	-0.41**	-0.52**	-0.83**	-0.32**	-0.52**	-0.42**	-0.64**	-0.48**

*P less than 0.05
**P less than 0.01

Table 11 (Continued)

Linear Slope Constants for Predictions of Task Percentage Baseline from Number of Hours of Continuous Work

Subject Number	Blinking Lights (Speed)	RED Warning Lights (Speed)	GREEN Warning Lights (Speed)	Probability (Accuracy)	Probability (Speed)	Arithmetic W/O CL (Attempted)	Arithmetic W/O CL (Accuracy)	Arithmetic W/ CL (Attempted)	Arithmetic W/ CL (Accuracy)	Target ID W/O CL (Attempted)	Target ID W/C CL (Accuracy)	Target ID W/ CL (Attempted)	Target ID W/ CL (Accuracy)	Mean Percentage of Baseline Performance
Males														
5-1	-0.50**	-0.30**	-0.10	-1.42**	-0.73**	-0.54**	-0.81**	-0.67**	-0.86**	-0.51**	-0.64**	-0.80**	-0.98**	-0.68**
5-2	-0.38*	-0.66*	-0.13	-0.85**	-0.55**	-0.08**	-0.12*	-0.27**	-0.28**	-0.32	-0.62*	-0.17*	-0.51**	-0.38**
5-3	-0.62**	-0.23	0.14	-0.40	-0.47	-0.91**	-1.14**	-0.97**	-1.22**	-0.99**	-1.14**	-0.79**	-1.37**	-0.78**
5-4	-0.52**	-0.41*	-0.36	-1.14**	-0.54**	-0.52	-0.60*	-0.74**	-0.80**	-0.99*	-1.07*	-0.90**	-1.19**	-0.75**
5-5	-0.63**	-0.12	-0.45*	-1.54**	-0.73**	-0.22**	-0.58**	-0.23**	-0.49**	-0.62*	-1.08**	-0.57	-1.09**	-0.64**
5-6	-0.40*	-0.20	-0.52*	-1.52*	-0.61*	-0.40*	-0.99*	-1.13**	-2.64**	-0.63*	-0.58**	-0.44*	-1.12**	-0.86**
5-7	-0.55**	-0.16	-0.06	-0.76**	-0.41**	-0.45*	-0.74**	-0.40	-0.46	-1.17**	-1.11**	-0.95**	-0.87*	-0.62**
5-8	-0.22	-0.06	-0.14	-1.03**	-0.46**	-0.83**	-1.01**	-0.96**	-1.00**	-0.29*	-0.50**	-0.31*	-0.78**	-0.58**
5-9	-0.50	-0.55**	-0.55	-1.03	-0.55*	-0.55**	-0.86**	-1.23**	-1.61**	-2.05**	-2.73**	-1.70**	-2.53**	-1.26**
5-10	-0.58**	-0.21*	-0.04	-1.79**	-0.89**	-0.04	-0.12	-0.40**	-0.45**	-0.91**	-0.98**	-0.65**	-0.69**	-0.60**
AvS	-0.49**	-0.29**	-0.22*	-1.15**	-0.60**	-0.45**	-0.70**	-0.70**	-0.98**	-0.85**	-1.05**	-0.73**	-1.11**	-0.72**

*P less than 0.05
**P less than 0.01

Examination of the results of these analyses reveal that the range of individual differences is not very wide; specifically, 34 of the 38 subjects included in these analyses exhibited significant negative slope constants relating time on duty and the index of general performance. The four subjects not showing significant overall decrements in performance as a function of time on duty were distributed as follows: two subjects in the Normal Menstrual group, one subject in each of the Normal Mid-Cycle and Pill Menstrual groups. Further, it is suggested that since the performance data were the percentage-of-baseline transformations of the original performance measures, the linear slope constants can be employed as indices of relative sensitivities of the individual measures to the effects of time on duty. For example, within the Normal Mid-Cycle group, based on the linear slope constants of the AvS, the most sensitive measure to the time on duty was the Accuracy measure of Probability with an average decrement of 1.16% from baseline per hour on duty. The least sensitive measure for that group was the Attempted measure of Arithmetic without Code Lock.

Similarly, a rank ordering of the five experimental groups in terms of their sensitivities to the time on duty dimension can be achieved by comparing the slope constants for the AvS on the Mean Percentage of Baseline Performance measure. For example, the least sensitive group according to this criterion was the Normal Menstrual group with an average decrement of 0.33% per hour of time on duty, followed by the Normal Mid-Cycle group with an average decrement of 0.44%, the Pill Menstrual group with 0.48%, the Pill Mid-Cycle with 0.68% and the Male group with 0.72% per hour of time on duty. It should be noted that while the linear slope constants do permit a rank ordering of the experimental groups, the slope constants accurately reflect the trend of performance over time only to the extent that the trend is linear.

A general summary of the results of the Training and Continuous-Work phases of this investigation can be expressed as follows: (a) with few exceptions, the five groups performed at comparable levels of performance through training and the baseline period; (b) all groups exhibited significant decrements in overall performance through 48 hours of continuous work and sleep loss; (c) the decrements in performance observed during the first 16 hours of continuous work and sleep loss were relatively minor and unsystematic with respect to group and specific measure of performance; (d) decrements observed during the second 16 hours of continuous work and sleep loss were universal with respect to group and, with the exception of the Normal Menstrual group, were universal with respect to measure of performance; (e) decrements observed during the final 16 hours of sleep loss and continuous work continued the trend observed during the second 16 hours with the Normal Menstrual group remaining the most resistant to the effects of sleep loss and continuous work and the Pill Mid-Cycle and Male groups being the least resistant to the effects of continuous work; and (f) individual differences among the subjects were noted with respect to their responses to the sleep loss and continuous work, with a few subjects (4 of 38) exhibiting essentially no decrements in overall performance over the 48 hours of continuous work.

The Cycling Phase

The design and purposes of the third phase of the present project dictate a different approach to the treatment of results. The design of this phase called for two groups of 15 female subjects--one group using contraceptive pills (hereafter referred to as the "Pill" group) and one group not using contraceptive pills (referred to as the "Normal" group)—to perform the tasks of the MTPB for 3 days per week for five consecutive weeks. The purpose of this phase was to compare the performances of the two groups of subjects to determine (a) if there were differences between the groups, and (b) if there was evidence of a menstrual-cycle effect in the performances. Inherent in the design and purposes of this phase is the problem that has plagued investigators of the menstrual cycle--namely, individual differences with respect to length of the menstrual cycle.

The approach taken in the treatment of the present data was one of converting the phases of the menstrual cycle of all subjects to deciles, based on the actual lengths of the subjects' cycles. Performances at the beginning of each decile of the menstrual cycle were obtained by (a) using obtained performance data if a measurement day coincided with the determined beginning of a decile, or (b) in the case where the beginning of a decile fell between two measurement days, interpolating the performance data to derive the performance score for the beginning of the decile. As a result of this manipulation of the data, the 13 individual performance measures of the MTPB were obtained for each of the subjects of the two groups for each of the decile points, and these derived data were used for the following analyses.

Since each of the subjects participating in this phase of the investigation had previously participated in the Sleep-loss and Continuous-work phase of the study, it was decided that for purposes of baseline comparison, a baseline established after the sleep loss would be more appropriate. It was further decided that for purposes of comparison, the baseline would be Ø - decile point--the onset of menstruation. Table 12 presents the mean baseline values obtained for each of the 13 performance measures for the two groups of subjects. Also presented with each of the sets of means are (a) the obtained t-value comparing the two groups on baseline value, and (b) the Pearson Product Moment Correlation Coefficient relating the new baseline values to the baseline values used in the Continuous-work phase. (The correlation coefficients were computed over the total 30 subjects). Two measures--the Accuracy measure of Target Identification Without Code Lock and the Attempted measure of Target Identification With Code

Table 12

Baseline Values for the Cycling Phase With Summary Statistics

Performance Measure	Normal Group	Pill Group	t-Value#	r
RED Warning Lights (Speed)	8.96	8.67	0.902	0.540
GREEN Warning Lights (Speed)	7.98	7.44	1.223	0.734
Blinking Lights (Speed)	5.69	5.73	0.098	0.787
Probability Monitoring (Accuracy)	65.11	60.39	0.407	0.777
Probability Monitoring (Speed)	580.84	589.69	0.204	0.777
Arithmetic W/O Code Lock (Attempted)	98.50	97.46	0.729	0.685
Arithmetic W/O Code Lock (Accuracy)	93.69	91.65	0.763	0.725
Arithmetic W/ Code Lock (Attempted)	96.33	95.50	0.437	0.934
Arithmetic W/ Code Lock (Accuracy)	89,61	89.46	0.045	0.734
Target ID W/O Code Lock (Attempted)	99.10	95.54	1.198	0.932
Target ID W/O Code Lock (Accuracy)	90.98	80.47	1.760*	0.877
Target ID W/ Code Lock (Attempted)	98.81	96.82	1.744*	0.750
Target ID W/ Code Lock (Accuracy)	89.52	83.68	1.184	0.866

*$\underline{P}$ less than 0.05
#$\underline{df}$ = 28

Lock--resulted in significant differences between the two groups, with the Normal group superior in both cases. Since only 2 of 13 comparisons resulted in significant differences, attributing of major importance to these effects is probably premature. The comparisons to follow were confined to the percentage-of-baseline transformation of the individual measures.

To assess the effects of the groups as well as the effects of the menstrual cycle, a series of Groups by Deciles (2 X 10) analyses of variance were computed using the percentage-of-baseline of the individual measures of performance and the Mean Percentage of Baseline Performance. Of the 14 sets of analyses, there were no measures that exhibited significant Group or Decile effects. There were 3 measures that showed significant Group-by-Decile interactions--Blinking Lights ($F = 2.061$, $df = 9, 252$, P less than .01), Speed measure of Probability Monitoring ($F = 2.383$, $df = 9, 252$, P less than .01), and Mean Percentage of Baseline Performance ($F = 2.301$, $df = 9, 252$, P less than .01). Figure 4 presents Mean Percentage of Baseline Performance as a function of Deciles for the two groups of subjects; the pattern of differences for the other two measures were similar in form. Examination of these interactions, using post-hoc comparisons, revealed that the significance is attributable to the divergence of the two groups beginning at Decile-1 and continuing through Decile-5, at which point the groups no longer differ.

In summary, the Cycling phase of this investigation appears to offer little evidence of a general menstrual-cycle effect on performance. The significant interactions noted above suggest, however, that there may be a difference between females who use contraceptive pills and females who are cycling normally during the first half of the menstrual cycle in terms of the speed with which they respond to watchkeeping tasks. However, in light of the number of comparisons performed using the cycling data, it should be noted that the observed differences could just as easily represent alpha errors.

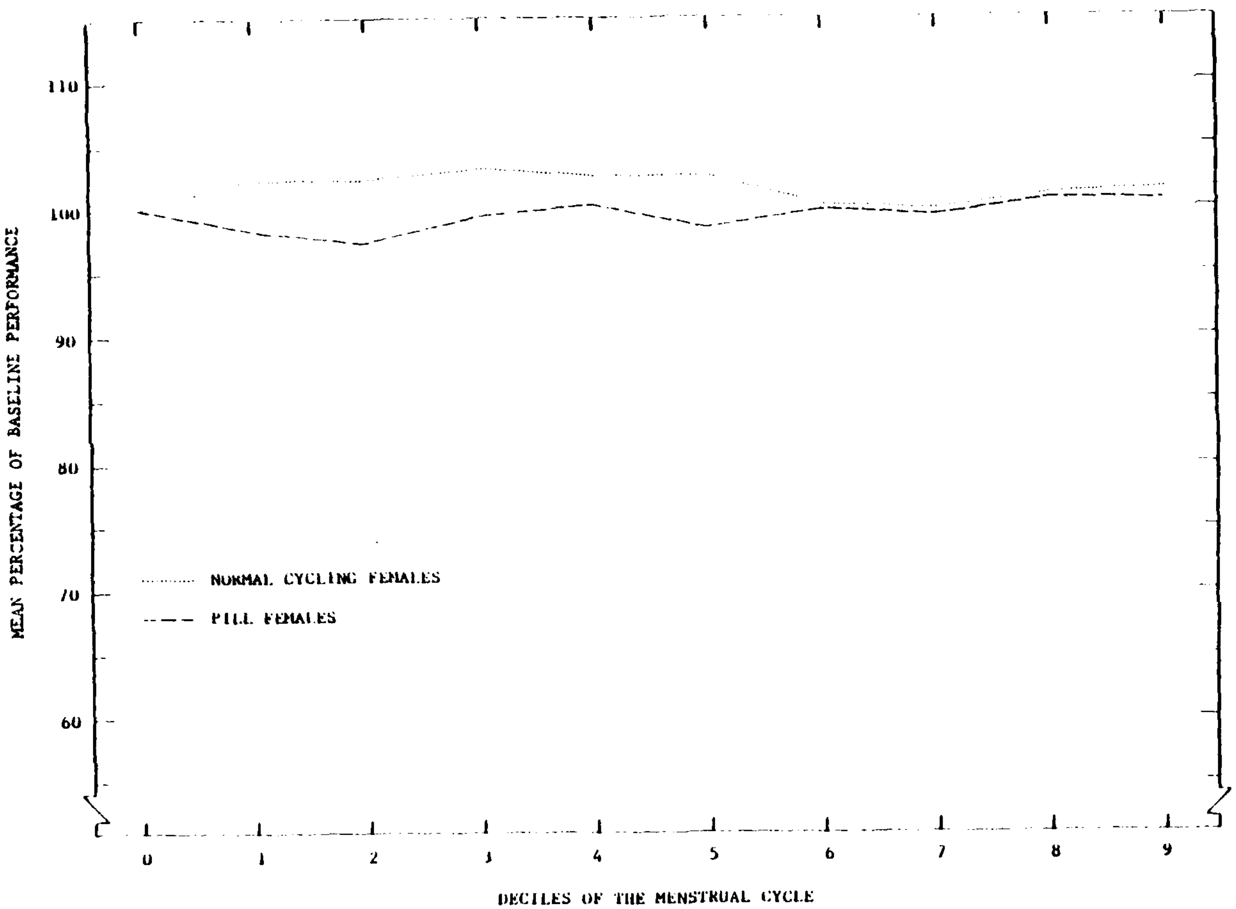

Figure 4: Mean Percentage of Baseline Performance for the Normally Cycling Females and Pill Females as a function of the deciles of the menstrual cycle. Baseline levels for these data was established as the performance levels at the onset of menstruation--Decile 0.

Discussion

The investigations reported herein represent the first systematic attempt to collect work-performance data for both male and female workers performing under identical conditions of training, normal work, and imposed stress. Further, the degree of control inherent in the utilization of the synthetic-work methodology of the MTPB permits direct comparisons of male and female work performances that will be possible in few real-world work situations. The results of these investigations indicate that during the period of training the female workers performed the tasks of the MTPB at levels equal to those of the male workers in terms of absolute levels and in terms of relative levels with respect to ultimate asymptotic levels of baseline. An initial difference in the Arithmetic task was noted during the early hours of training (one female group differed from all other female and male groups), but this difference disappeared after about eight hours of training. During the baseline period following training, all groups were performing at essentially identical levels. During the period of stress imposed by 48 hours of sleep loss and continuous work, the results indicate that the responses of the female workers in general were the same as the responses of the male workers--the performances of the female groups were equal to or, in some cases, superior to those of the males.

The contributory significance of this comparability, on the one hand, lies in the fact that a large body of data has been accumulated using male subjects performing the tasks of the MTPB under conditions of stress imposed by sleep loss and continuous work that are now applicable, with caution, to the performances of female subjects under those conditions also. Although investigations should be conducted verifying the results of previous findings with female subjects, based on the data of the present investigation, there is no reason to assume that females in general will perform differently from the males. On the other hand, although males and females performed at comparable levels, of equal significance are the differences that were observed.

Although the performances of all groups were maintained at essentially equal levels through the training and baseline periods and approximately 32 hours of the sleep-loss period, differences among the groups began to emerge during the last 16 hours of the sleep loss. On the one hand, the performances of the Normal Menstrual group revealed a maximum decrement in overall performance of approximately 18.1% of baseline; on the other hand, the maximum decrements observed for the Pill Mid-Cycle and Male groups were 36.7% and 33.9% of baseline, respectively. The differences between the Normal Menstrual group and the latter two groups were each statistically significant. Though not statistically significant from any group, the maximum decrements observed in the Normal Mid-Cycle and Pill Menstrual groups were 24.3% and 30.4% of baseline, respectively. The effects of the sleep-loss and continuous-work period for each of the groups may be better summarized by the average slope constant relating the general index of MTPB performance to the number of hours of continuous work. For example, the average decrement in performance for the Normal Menstrual group during the sleep loss period was 0.33% per hour of continuous work. Similarly, the coefficients for the other groups were 0.44% per hour for the Normal Mid-Cycle group, 0.48% for the Pill Menstrual group, 0.68% for the Pill Mid-Cycle group, and 0.72% per hour for the Male group. Except as noted above, the differences among these groups did not achieve statistical significance. However, the trends noted in each of the indices (maximum decrement and slope constant) are noteworthy.

With caution it should be noted that the two groups of female subjects who were not using contraceptive pills (i.e., the Normal groups) were least affected by the sleep loss and continuous work while the effects on the females who were using contraceptive pills were more similar to the effect on the male groups.

In a similar vein, it should be noted that within the female groups, the effects of sleep loss and continuous work were less for the groups who were menstrual during the sleep loss period than for those females who were at mid-cycle at the time of sleep loss. While these trends do not achieve statistical significance, they should be noted for further investigation. For example, the tendency for the menstrual females to resist the effects of sleep loss and continuous work more effectively than the mid-cycle females runs counter to many of the findings regarding menstrual-cycle effects and the general view of the working female as she is affected by her menstrual cycle. The tendency of the normally cycling females to perform at a higher level under sleep-loss stress than the pill cycling females is also a tendency that needs further investigation. It is suggested, therefore, that future studies of the effects of sleep loss and continuous work on female workers should incorporate the two dimensions (i.e., Menstrual vs Mid-cycle and Normal vs Pill) for further examination.

As noted, the Cycling phase of this investigation, with minor exceptions, failed to identify any effect of the various stages of the menstrual cycle on normal work performance. The only noted differences in this phase was an improvement in the Speed measures of two watchkeeping tasks during the first half of the menstrual cycle for the normally cycling females. All other measures of work performance for the two groups of females over a complete menstrual cycle reflected very little variability from baseline levels. It should be noted that the Cycling phase of this investigation was conducted after each subject had performed the tasks of the MTPB for approximately 128 hours. Therefore, the subjects were performing at asymptotic levels representative of levels expected in the work situation; at such levels of performance, a stressful agent must have a "sledgehammer" effect in order for it to affect detrimentally the performance of the workers. Based on the data of this investigation, the effects of the menstrual cycle do not represent such effects when examined independent of other stressful agents. It is suggested, however, that the interaction of the menstrual cycle with other stressors remains a fruitful area for investigation as noted above. Further, it should be noted that the data of this investigation do not address the question of the effects of the menstrual cycle prior to the achievement of asymptotic levels of performance; the effects of the menstrual cycle during the training phase remain an area of investigation worthy of further study.

As noted earlier, the results of this project are missing an entire dimension of performance that should be investigated further. Specifically, because of the experimental design of this project, an analysis of the group-performance task was not meaningful. The Code-Lock Solving task of the MTPB was employed in this project strictly as a task to provide comparable work loads for the subjects. It is conceivable, therefore, that the subjects within the experimental groups adopt differential strategies with respect to the group task which, in turn, affect their performances on the individual tasks. Thus, it is suggested that further investigations should be conducted that employ intact crews that satisfy the criteria used to define the experimental groups of the present project; for example, an intact crew composed of normally cycling females who are menstrual at the onset of the sleep-loss period. In this way, the performances on the group task can be examined in conjunction with the performances on the individual tasks to determine if in fact differential strategies are employed. The design of the present project was dictated by our desire to minimize demand characteristics associated with the phases of the menstrual cycle; while the subjects were aware that they were selected on criteria related to the menstrual cycle, emphasis in the briefing was placed on this selection as a means of experimental control. Thus, the goal was to obtain data uncontaminated by what the subjects thought should be their role based on their particular phase of the menstrual cycle. Nevertheless, the role of the group-performance task is an important one and should be a major consideration in the design of future studies.

In conclusion, the present project has produced an interesting set of results that suggest a number of directions one should take in research involving work performances of male and female workers. However, it should be emphasized that the relatively small number of subjects employed in this project dictates that these results are tentative. Additional investigations are needed within the dimensions of the present project--additional comparisons of the performances of male and female subjects in the synthetic-work situation, additional examinations of the interaction of sleep-loss stress and the menstrual cycle, and additional comparisons of the performances of normally cycling females with those of females using contraceptive pills. It is only through these additional investigations that the significance of the present project will be realized.

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APPENDIX A

RESEARCH METHODOLOGY OF THE SYNTHETIC-WORK TECHNIQUE

Prepared by Ben B. Morgan, Jr. and Earl A. Alluisi

A synthetic-work approach (Alluisi, 1967, 1969; Chiles, et al., 1968) has been developed to provide measurements of multiple-task performance obtained within the domain of work behavior. The basis for this approach is a laboratory work situation that is created by combining into a synthetic job six tasks that represent functions which man is called upon to perform in just about any job. No specific system has been simulated directly, but a generalized system has been devised in terms of the performance functions represented in many different systems. The data obtained from use of the synthetic-work approach, therefore, are applicable to a wide variety of specific systems that employ the same functions.

These functions (and the tasks used in measuring their performance) are the (a) watchkeeping, vigilance, and attentive functions (warning-lights, blinking-lights, and probability monitoring), (b) memory functions, both short- and long-term (arithmetic computations), (c) sensory-perceptual functions (target identification), (d) procedural functions, including such things as interpersonal coordination, cooperation, and organization (code-lock solving), (e) communication functions, including the reception and transmission of information (not directly measured, but involved in all active tasks of the MTPB), (f) perceptual-motor functions (no direct measure), and (g) intellectual functions (no direct measure). Tasks designed to measure directly certain nonverbal-mediational aspects of intellectual functioning (cf. Alluisi & Coates, 1967; Alluisi & Morgan, 1968), and a kind of decision-making behavior (cf. Rebbin, 1969) are under development. Some attempts have also been made to employ tracking tasks with the MTPB (e.g., Adams, Levine, & Chiles, 1959; Chambers, Johnson, Van Velzer, & White, 1966).

Behavioral measures of five of these functions are obtained from the operator's performance in working at the six tasks, which are generally displayed at each of five identical work stations arranged as was shown in Figure 2 of the present report; there is one work station for each member of a 5-man crew. Subjects are typically required to occupy these work stations for 8 hr per day, and to work at the MTPB tasks as they would any other job.

MTPB TASKS

Several similar multiple-task performance batteries have been used in the synthetic-work approach to the study of sustained performance. In the MTPB used at the University of Louisville, the tasks are displayed on each of five identical (approximately 12 in high and 20 in wide) instrument or MTPB-operator panels; the front view of one such panel was shown schematically in Figure 1 (p. 4). Reference should be made to this figure in order to understand the task descriptions given below.

Warning-Lights monitoring.--One of the three watchkeeping tasks is presented with a pair of warning lights, one green and one red, located on the extreme left of the panel. The normal state for this task is for the green light to be lit and the red light unlit. At random intervals of time, when a signal is presented, there is a change of state and the subject is required to turn the green light on should it go off, or the red light off should it come on, by pressing a push button located immediately below the light in question. If the subject fails to respond within 2 min, the non-normal condition is corrected and he is scored with a maximum latency. The subject's latency in responding to each non-normal identification is recorded on a 0.1 sec timer, but prior to analysis it is transformed to a normalized speed score (cf. Alluisi, Thurmond, & Coates, 1967, Ap. D, p. 79).

Blinking-Lights monitoring.--On the extreme right of the panel there is a pair of vertically arranged amber lights that are employed to present a second watchkeeping task. Under normal conditions the two lights flash alternately at an over-all rate of two flashes per second. The critical signal is an arrest of this alternation in which either the top or the bottom light flashes at twice its usual rate. The duration of each flash, both in the normal and arrested condition, is 0.25 sec. If the subject fails to respond within 2 min, the non-normal condition is corrected and he is scored with a maximum latency. This task has been recently added to the battery, and was initially used in BEID-1 (cf. Alluisi, et al., 1967, p. 58); there are prior research findings on which it is based (cf. Chinn & Alluisi, 1964; Smith, Warm, & Alluisi, 1966).

The length of time during which the critical signal is present is recorded on a 0.1-sec timer, but prior to analysis this latency score is transformed to a normalized speed score (cf. Alluisi, et al., 1967, Ap. D, p. 79).

Probability monitoring.--Four semicircular scales located along the upper portion of the panel are used to display the probability-monitoring task. A pointer on each scale is driven by a random program generator. The pointer settings are normally distributed with a mean of zero (12 o'clock position on the scale) and a known standard deviation. Introduction of a bias to the programming device causes the mean of the distribution on one of the four scales (different on different panels) to shift by a specified amount (usually one standard deviation). This shift in the mean does not affect the variability of the pointer positions.

When the subject detects a shift in the mean, he indicates this by pressing a push button under the meter in question--the left push button if he has detected a bias-to-the-left, and the right push button for a bias-to-the-right. Whenever the subject pushes any of the probability-monitoring push buttons, the pointer of the meter in question moves to and stabilizes at the mean of its current distribution (i.e., either zero, or biased right or left). If a bias is present, then a correct response by the subject causes the scale to be reset to a zero-bias condition.

Data recorded are the number of bias signals presented, the number of bias signals detected correctly, the number of false responses, and the time required to detect each bias correctly. Data analyzed are the percentage of signals correctly detected, and a measure of the speed of detection (800 sec--the longest intersignal interval--minus the mean detection time).

Arithmetic computations.--Three, 3-digit numbers are displayed along the lower central portion of the panel by means of nine, 1-digit numerical indicators. The operator is required to subtract the third 3-digit number from the sum of the first two. He indicates his answer by manipulation of four decade thumb switches immediately to the right of the indicators, and a push button just to the left and slightly above the switches.

Depression of the push button will cause the response to be recorded automatically. If the answer is correct, a blue indicator light (immediately above the numerical indicators, and just to the right of center) is lit for a 1/2-sec interval as the problem is removed and just prior to the presentation of a new problem.

Problems are presented at a rate of three per minute during the 30-min intervals allocated to the performance of arithmetic computations in each 2-hr work period. An amber indicator light (immediately above the numerical indicators, and just to the left of center) is lit 30 sec prior to the presentation of the first problem and it remains lit throughout the 30 min. Ten different random orders of a basic set of 570 problems are used--one order each day for the first 10 days of testing, then a simple replication of order 1 on Day 11, 2 on Day 12, etc. Each order is divided into six sections of 95 problems, from which are drawn the 90 problems presented during each 30-min period of arithmetic computations. Subjects are scored in terms of (a) the percentage of problems attempted and (b) the percentage of problems correctly answered.

Target identification.--In the center of each subject's panel there is a 4-in square array of 36 close-butted, square lights. These lights, which form a 6-by-6 matrix, are used to present the "metric histoforms" that are employed in the target-identification task. These are contoured figures consisting of lit and unlit elements that give the appearance of solid bar graphs.

A finite set of 240 metric histoforms has been drawn at random from the 720 possible 36-element constrained figures (figures in which each of the six possible column heights appears once and only once). Each of these 240 figures is programmed to appear with its base at 6 o'clock (i.e., with column rising) to represent a "stored" image. Another set of figures, drawn from the same basic set of 720, is used to represent "sensed target" images. These latter figures are randomly positioned so that the base of a figure can occur at 12, 3, 6, or 9 o'clock.

The task typically presented to the subject is as follows: There is a 5-sec display of the upright figure, or stored image. This is followed by a 5-sec "off" period. Then there is a 2-sec display of a randomly positioned image (sensed Target-A), a 2-sec off period, and a 2-sec display of a second randomly positioned image (sensed Target-B). After a response period of 14 sec, the cycle is repeated with a new stored image and new sensed target images.

Each subject is required to respond by use of one of three push buttons (to the left, just below the display) to indicate whether in his judgment the stored (upright) image was the same as the first, second, or neither of the sensed target images. The subject's response is indicated on his panel by the amber light above the push button; the appropriate light is lit when he makes his response and remains lit until extinguished when the problem is cycled and a new problem presented. When this is done, and just before a new problem appears, a blue knowledge-of-results indicator light is lit for a 1/2-sec interval to inform the subject regarding the correct response to the problem.

The basic set of 240 stored upright images is programmed in a constant order on each of 10 different punched tapes, but the answer orders and the "different" images on each of these tapes are random and different within the restriction that in each case an equal number of the three responses is called for. Records are made of the total number of responses and the number of correct responses made by each subject. Data analyzed are the percentage of problems attempted and the percentage of problems responded to correctly.

<u>Code-lock solving</u>.--As presently constituted, the code-lock task is a group-performance task that involves principally procedural functions. The task requires the crew to discover the proper sequential order for depressing five push buttons--one for each of the five members of the crew. Three jewel indicator lights (red, amber, and green) and two push buttons (one a spare) are located on each of the five panels in the center-right portion between the target-identification and the blinking-lights displays.

Illumination of the red light is the signal that a problem is present and unsolved. The amber light is illuminated when any subject depresses his push button, but with no indication as to which subject it was or whether it was just one or more than one who did so. The problem is solved only when each of the five push buttons has been depressed in the correct sequential order for the specific problem.

Thus, the red light is extinguished when the correct first subject in the sequence depresses his push button, and it will remain extinguished until an incorrect response is made. When such an erroneous response does occur, the red light is re-illuminated, and the programming apparatus is reset automatically to the beginning of the sequence. In order to recommence the search for a solution, the correct first subject must depress his button first, then the correct second subject must depress his button, etc. When all five push buttons have been depressed in the correct order, the green light is illuminated as a signal that the problem has been solved.

Following a between-problem pause of 30 sec, the green light goes off, the red light comes on, and the crew is presented with a replication of the problem previously solved. This requirement for a "second solution" is included to increase the sensitivity of the task to performance decrements. Following the second solution and a between-problem pause of 30 sec, the green light goes off, the red light comes on, and the crew is presented with a new sequence or code to solve.

Several measures of crew performance are employed: Records are made of the time required for code-lock solutions, the total number of responses made, and the number of errors (or programmer resettings). In addition, the data analvzed includes the mean number of sequences solved per unit time--a measure that is linearly related to the relative information transmission rate per period, and equally weighted on the speed and accuracy factors that have been identified (cf. Alluisi, Chiles, & Hall, 1963, pp. 28-32).

General.--The six tasks were selected to meet certain criteria of validity, sensitivity, engineering feasibility, reliability, flexibility, work-load variability, trainability, and control-data availability (cf. Alluisi, 1967, 1969; Alluisi & Fulkerson, 1964, pp. 5-6; Chiles, et al., 1968). In addition, three of the tasks were selected initially on the basis of an analysis of individual operator requirements for long-range, long-endurance weapons systems (cf. Adams, 1958; Chiles, et al., 1968). The three remaining tasks represent either modifications intended to improve the tasks already in use, or additions to extend the range of functions measured with the performance required by the battery. All of the tasks show very high reliabilities (see Alluisi, 1967; Alluisi, Hall, & Chiles, 1962; Chiles, et al., 1969), and have done so since their earliest use (Adams, et al., 1959). Several of the tasks have been described in previous reports: (a) arithmetic computations, probability monitoring, and warning-lights monitoring by Adams and Chiles (1960, pp. 4-6; 1961, Ap. III), (b) code-lock solving by Alluisi, Hall and Chiles (1962, pp. 5-6), (c) target identification by Alluisi, Chiles, Hall, and Hawkes (1963, pp. 4-6), and (d) blinking-lights monitoring by Alluisi and Fulkerson (1964, p. 12). The tasks contained in the current MTPB are nearly identical to those employed in a prior version of the battery (see Alluisi, et al., 1964, Ap. I); the tasks were described prior to the construction of the equipment (Alluisi & Fulkerson, 1964, pp. 10-14) and after their use in previous studies of the behavioral effects of infectious diseases (Alluisi, et al., 1967, Ap. A; Coates, Thurmond, Morgan, & Alluisi, 1969, Ap. A; Thurmond, Alluisi & Coates, 1968, Ap. A).

TASK SCHEDULE

The six MTPB tasks are synthesized into a reasonably realistic work-like situation--a situation that requires the operator to be responsible for the time-sharing of functions at various levels of work load. The work is typically divided over a 2-hr performance period so that the operator is responsible all of the time for the three watchkeeping tasks, but only part of the time for the three active tasks; (a) arithmetic computations during 30 sec of each 2-hr period, 15 min in combination with the watchkeeping task only, and 15 min with the group-performance procedural task of code-lock solving as well, (b) code-lock solving during half of each 2-hr period, 15 min with arithmetic computations and watchkeeping, 30 min with watchkeeping alone, and 15 min with watchkeeping and target identification, and (c) target identification during 30 min, half as indicated (with watchkeeping and code-lock solving) and half with the watchkeeping tasks only. Thus, relative demands on performance are low, intermediate, or high, depending on whether the watchkeeping tasks are presented alone, with only one of the active tasks, or with two (or more) of them. The 2-hr performance schedule typically used was shown in Table 1 (p. 6). When subjects are required to work for 8 hr a day, this schedule is repeated four times during the day. However, from the subject's point of view, there is no break between repetitions of the program from the start to the end of a period of testing since the three watchkeeping tasks (warning-lights, blinking-lights, and proability monitoring) are presented continuously at each work station.

INITIAL RESEARCH PROGRAM

The development of the synthetic-work technique and research use of the MTPB began in 1956 when the Aerospace Medical Research Laboratories, Wright-Patterson Air Force Base, Ohio, began a program of research on crew performance; much of the research was conducted under contract at the Human Factors Research Laboratory of the Lockheed-Georgia Company, Marietta, Georgia. The plan was to conduct research on crew performance applicable to advanced systems of a general class, "ten years in the future;" major emphasis was placed on operator performances of the functional aspects of mission-related tasks. A group of tasks was assembled, the performance panels, programming and scoring apparatus, experimenters' control consoles, and crew compartments were designed and constructed (see Adams, 1958), and an initial experiment was then conducted to answer certain technical questions concerning the tasks of the MTPB--questions such as those related to task reliability and intertask correlations (see Adams, et al., 1959).

Among the variables investigated in later studies were the following: (a) the work-rest cycle (8 hr on-duty and 8-hr off, 6 hr on and 6 off, 4 on and 4 off, and 2 on and 2 off); (b) the work-rest ratio (1:1, 2:1, and 3:1); (c) the operator's work load; (d) the addition of group-performance tasks; (e) the total duration of the period of confinement in the crew compartment (4 hr, 4 days, and 12, 15 and 30 days); (f) the effects of 2 days of sleep loss on performance under two demanding work-rest schedules (4-2 and 4-4); (g) the elementary relations between the performance measures obtained and two biomedical measures (temperature and pulse rate); and (h) samples of subjects who represented different populations (college students, including ROTC and Air Force Academy cadets, operational B-52 crews, and Air Force Officers newly graduated reported in a series of Air Force technical reports (Adams & Chiles, 1960; 1961; Alluisi, et al., 1962, 1963, 1964).

The conclusions reached on the basis of this decade of research on sustained performance, work-rest scheduling, and circadian rhythms in man, may be summarized as follows: (a) Man can probably follow a 4-4 work-rest schedule for very long periods without detriment to his performance. (b) For shorter periods of 2, or possibly 4 weeks a more demanding 4-2 work-rest schedule can be followed by selected men with reasonable maintenance of performance efficiency. (c) In following the more demanding schedule, man uses up his performance reserves, and so is less able to meet the demands of emergency conditions such as those imposed by sleep loss. (d) the circadian rhythm that is evidenced in physiological measures may also be evidenced in the performance measures, depending on the information given to, and the motivation of, the subjects and depending also on the total workload; even where motivation is sufficiently high, the cycling may be demonstrated in the performances of overloaded operators. Finally, (e) the MTPB and methodology employed in the synthetic-work approach have yielded measures that are sensitive to the manipulation of both obvious and subtle experimental variables; continued use and refinement of both should lead to further advances in the general area of performance-assessment research (cf. Alluisi, 1969; Alluisi & Chiles, 1967; Chiles, et al., 1968).

RECENT RESEARCH FINDINGS

A more recent series of investigations of sustained performance has been directed toward the assessment of the Behavioral Effects of Infectious Diseases (BEID). This research program consisted of two control studies conducted at the Performance Research Laboratory of the University of Louisville, and six illness-related studies conducted at the U.S. Army Medical Research Institute of Infectious Diseases (USAMRIID), Fort Detrick, Maryland. These studies have been summarized elsewhere (Alluisi, 1969; Alluisi, Beisel, Bartelloni, & Coates, 1973; Beisel, Morgan, Bartelloni, Coates, DeReburtis, & Alluisi, 1974).

In its entirety, the BEID research program consisted of the following studies: (a) BEID-1 was a control study that provided comparison data for the remainder of the experiments. The BEID-1 subjects were uninfected, and they performed at levels essentially identical to those of subjects in previous MTPB experiments as well as the hospital-control subjects of subsequent BEID studies (Alluisi, Thurmond, & Coates, 1971). (b) BEID-2 and BEID-3 were investigations of the effects of illness with Pasteurella tularemia (commonly termed "tularemia" or Rabbit fever) on sustained performance (Alluisi, et al., 1971; Thurmond, Alluisi, & Coates, 1971). (d) BEID-4 and BEID-5 were investigations of the effects of illness with Phlebotomus fever (commonly called "Sandfly fever") on sustained performance and muscular output (Coates, Thurmond, Morgan, & Alluisi, 1972; Morgan, Coates & Alluisi, 1973). (d) BEID-7 was an investigation of the effects of symptomatic treatment on the performance of subjects infected with Phlebotomus fever. (e) BEID-8, the latest study in the series, was designed to provide additional control data for BEID-7. It investigated the effects of treatment (identical to that given in BEID-7) on the performance of 10 uninfected subjects (see Beisel, et al., 1974 for summary of BEID-7 and -8). The two diseases involved in these studies are quite similar in terms of symptomatology except for intensity, but they do differ in terms of etiology: Tularemia results from a bacterial infection, whereas the infectious agent in Sandfly fever is viral. Both infections produce fever, frontal and retro-orbital headache, photophobia, generalized malaise, arthralgia, and leukopenia.

The conclusions reached from the findings of the BEID program may be summarized as follows: (a) In general, the average efficiency of performance on the MTPB dropped between 25% and 33% during the period of illness with tularemia. The average drop in performance efficiency was between 6% and 8% per 1°F rise in rectal temperature. (b) the results of studies involving the less-severe illness, Sandfly fever, indicate that average crew performance dropped between 18% and 25% during the period of illness with this disease. The average drop in performance in these studies ranged from 3% to 6% per 1°F rise in rectal temperature. (c) With both diseases, the individual reactions to illness produced substantial individual differences in terms of performance decrements; subjects who were equally and fully ill (as judged clinically and measured biomedically) yielded performance decrements that ranged from essentially no decrement to one of 17% to 20% per degree rise in temperature. Current studies of these individual differences and their psychophysiological and biomedical correlates, as well as their personality, social, and subjective correlates, are continuing, but to date have produced no clearer understanding of their causes.

APPENDIX B

SCHEDULES OF PERFORMANCE TESTING FOR BRASP 1, 2, 3, 4, 5, 6, & 7

BRASP-1: AGENDA AND SCHEDULES

The agenda and schedules used in BRASP-1 are presented on the following pages. They were distributed (along with the table presenting the basic 2-hr. task performance schedules) to the subjects during the orientation period on the morning of 18 February 1978.

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- - SAMPLE - -

CONSENT AND RELEASE STATEMENT

I,______________________________________, without duress and of my own free will do hereby consent to participate in a research study conducted by the personnel of the Performance Assessment Laboratory, Department of Psychology, Old Dominion University, Norfolk, Virginia, and the ODU Research Foundation, involving tasks of the multiple-task performance battery (MTPB). I understand that participation in this study will require that I work according to the schedule outlined in PAL MEMORANDUM NO. AFOSR-3512-17, dated 10 May 1979. The memorandum is attached and made a part hereof. In addition, I understand that for the second phase of this study, I will work during the week of 28 May - 3 June 1979, according to the work schedule outlined in Table 3 of the attached PAL MEMORANDUM NO. AFOSR-3512-17, involving a period of 48 hours of sleep loss and continuous work, preceded by two days of eight hours of work per day, followed by 24 hours of rest and recovery, followed by an additional two days of eight hours of work per day. In addition, I understand that the first 12 hours of the rest and recovery period must be spent within the confines of the experimental site at 1411 W. 49th Street, Norfolk, Virginia. In addition, I understand that I am required to submit in writing on a form supplied by the Chief Experimenter, indicated below, evidence of a physical examination, including a gynecological examination, by a physician of my choosing and at the expense of the Performance Assessment Laboratory. In addition, I understand that subsequent to the week of 28 May - 3 June 1979, I will be required to work for 12 hours per week for five additional weeks according to the schedule outlined in Table 1 of PAL MEMORANDUM NO. AFOSR-3512-16. The purpose, rationale and implications of the study have been explained to me. I consent to this research and agree to participate for the consideration of $10.00. I understand that on successful completion of the first phase of the study, I shall be awarded a stipend of honorarium of $100.00. I understand that for the second phase of the study and on successful completion of the week of 28 May - 3 June 1979, as a participant, I shall be awarded a stipend of honorarium of $250.00 and that on successful completion of the final five weeks of the second phase of the study, I shall be awarded a stipend of honorarium of $300.00. In addition, I understand that this research study is approved by the Old Dominion University and the ODU Research Foundation and as such will be recorded in the official files of the Performance Assessment Laboratory and the ODU Research Foundation. Finally, I understand that a probability of risk is involved in this procedure, and that I may withdraw from participation in this study at any time without threat of penalty.

____
(Signature) (Date)

WITNESS:

____
(Signature) (Date)

____
(Signature) (Date)

____
(Signature) (Date)

Reviewed and Approved: ______________________________________
(Signature) (Date)

- - SAMPLE - -

Table B-1

General Schedule, Brasp-1

Dates	Day (or Week)	No. of Hours	Activity
18 February 1978	Saturday	4	Briefing and MTPB Familiarization
20-21 February 1978	Monday - Tuesday	4	Training (Table B-2)
22-25 February 1978	Week #1	12	Testing (Table B-3)
27 February - 4 March	Week #2	12	Testing
6-11 March 1978	Week #3	12	Testing
13-18 March 1978	Week #4	12	Testing
20-26 March 1978	Week #5	80	Sleep loss (Table B-4)
27 March - 1 April	Week #6	12	Testing
3-8 April 1978	Week #7	12	Testing
10-15 April 1978	Week #8	12	Testing
17-22 April 1978	Week #9	12	Testing
24-29 April 1978	Week #10	12	Testing and Debriefing

*Final subjects for this phase of the study will be selected during this week.

Table B-2

Schedule of Training

Date	Crew	Time (Hours)	Training Activity
20 February 1978	ABLE	1400	Arithmetic and Monitoring
	ABLE	1500	Target ID and Monitoring
	ABLE	1600	Code Lock and Monitoring
	ABLE	1700	Combination of Tasks
21 February 1978	BAKER	1500	Arithmetic and Monitoring
	BAKER	1600	Target ID and Monitoring
	BAKER	1700	Code Lock and Monitoring
	BAKER	1800	Combination of Tasks

Table B-3

Schedule of Testing

Crew	Days	Times (Hours)
ABLE	Monday	1400 -- 1800
	Wednesday	1400 -- 1800
	Friday	1300 -- 1700
BAKER	Tuesday	1500 -- 1900
	Thursday	1500 -- 1900
	Saturday	0800 -- 1200

Table B-4

Work Schedule During Week of Sleep Loss and Continuous Work

DATE	DAY OF WEEK	TIMES OF WORK	HOURS WORKED
20 March 1978	Monday	0800 -- 1200	4
		1600 -- 2000	4
21 March 1978	Tuesday	0800 -- 1200	4
		1600 -- 2000	4
22 March 1978	Wednesday	0800 -- 2400	16
23 March 1978	Thursday	0000 -- 2400	24
24 March 1978	Friday	0000 -- 0800*	8
25 March 1978	Saturday	0800 -- 1200	4
		1600 -- 2000	4
26 March 1978	Sunday	0800 -- 1200	4
		1600 -- 2000	4
		Total Hours Worked	80

*A 24-hour rest and recovery period will begin at 0800 on this day. NOTE: the first 12 hours of the rest and recovery period must be spent in the Performance Assessment Laboratory.

BRASP-2: AGENDA AND SCHEDULES

The agenda and schedules employed in Brasp-2 are given on the following pages. These were distributed (along with the table presenting the basic 2-hr. task performance schedule) to the subjects during pretest interview and training periods on the afternoon of 21 April 1978.

Table B-5

General Schedule, BRASP-2

Date	Day (or Week)	No. of Hours	Activity
21 April 1978	Friday	4	Briefing and MTPB Familiarization
22 April 1978	Saturday	4	Training (Table B-6)
24-29 April 1978	Week #1	12	Testing
8-13 May 1978	Week #2	20	Testing
15-20 May 1978	Week #3	16	Testing
22-28 May 1978	Week #4	80	Sleep Loss (Table B-7)
29 May - 3 June	Week #5	12	Testing
5-10 June 1978	Week #6	12	Testing
12-17 June 1978	Week #7	12	Testing
19-24 June 1978	Week #8	12	Testing
25 June - 1 July	Week #9	12	Testing

Table B-6

Schedule of Training

Date	Crew	Time (Hours)	Training Activity
22 May 1978	ABLE	1400	Arithmetic and Monitoring
	ABLE	1500	Target ID and Monitoring
	ABLE	1600	Code Lock and Monitoring
	ABLE	1700	Combination of Tasks

Table B-7

Work Schedule During Week of Sleep Loss and Continuous Work

DATE	DAY OF WEEK	TIMES OF WORK	HOURS WORKED
22 May 1978	Monday	0800 -- 1200	4
		1600 -- 2000	4
23 May 1978	Tuesday	0800 -- 1200	4
		1600 -- 2000	4
24 May 1978	Wednesday	0800 -- 2400	16
25 May 1978	Thursday	0000 -- 2400	24
26 May 1978	Friday	0000 -- 0800*	8
27 May 1978	Saturday	0800 -- 1200	4
		1600 -- 2000	4
28 May 1978	Sunday	0800 -- 1200	4
		1600 -- 2000	4
		Total Hours Worked	80

* A 24-hour rest and recovery period will begin at 0800 on this day. NOTE: The first 12 hours of the rest and recovery period must be spent in the Performance Assessment Laboratory.

BRASP-3: AGENDA AND SCHEDULES

The agenda and schedules employed in Brasp-3 are given on the three pages that follow. These were distributed (along with the table presenting the basic 2-hr. task performance schedule) to the subjects during pretest interview and training periods on the morning of 24 June 1978.

Table B-8

General Schedule, Brasp-3

Date	Day (or Week)	No. of Hours	Activity
24 June 1978	Saturday	4	Briefing and MTPB Familiarization
27 June 1978	Tuesday	4	Training (Table B-9)
28-30 June 1978	Week #1	12	Testing
4-7 July 1978	Week #2	16	Testing
10-14 July 1978	Week #3	20	Testing
17-23 July 1978	Week #4	80	Sleep loss (Table B-10)
24-28 July 1978	Week #5	12	Testing
31 July - 4 Aug 1978	Week #6	12	Testing
7 Aug - 11 Aug 1978	Week #7	12	Testing
14 Aug - 18 Aug 1978	Week #8	12	Testing
21 Aug - 25 Aug 1978	Week #9	12	Testing

Table B-9

Schedule of Training

Date	Crew	Time (Hours)	Training Activity
27 June 1978	ABLE	1300	Arithmetic and Monitoring
	ABLE	1400	Target ID and Monitoring
	ABLE	1500	Code Lock and Monitoring
	ABLE	1600	Combination of Tasks

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Table B-10

Work Schedule During Week of Sleep Loss and Continuous Work

Date	Day of Week	Times of Work	Hours Worked
17 July 1978	Monday	0800 -- 1200	4
		1600 -- 2000	4
18 July 1978	Tuesday	0800 -- 1200	4
		1600 -- 2000	4
19 July 1978	Wednesday	0800 -- 2400	16
20 July 1978	Thursday	0000 -- 2400	24
21 July 1978	Friday	0000 -- 0800*	8
22 July 1978	Saturday	0800 -- 1200	4
		1600 -- 2000	4
23 July 1978	Sunday	1600 -- 2000	4
		Total Hours Worked	80

* A 24-hour rest and recovery period will begin at 0800 this day. NOTE: The first 12 hours of the rest and recovery period <u>must</u> be spent in the Performance Assessment Laboratory.

BRASP-4: AGENDA AND SCHEDULES

The agenda and schedules used in Brasp-4 are presented on the following pages. They were distributed (along with the table presenting the basic 2-hr. task performance schedules) to the subjects during the orientation period on the morning of 2 December 1978.

Table B-11

General Schedule, BRASP-4

Date	Day (or Week)	No. of Hours	Activity
2 Dec 1978	Saturday	4	Briefing
5 Dec 1978	Tuesday	4	Training (Table B-12)
7-9 Dec 1978	Week #1	8	Testing
18-23 Dec 1978	Week #2	24	Testing
2-6 Jan 1979	Week #3	16	Testing
8-14 Jan 1979	Week #4	80	Sleep Loss (Table B-13)
15-19 Jan 1979	Week #5	12	Testing
22-26 Jan 1979	Week #6	12	Testing
29 Jan - 2 Feb 1979	Week #7	12	Testing
5-9 Feb 1979	Week #8	12	Testing
12-16 Feb 1979	Week #9	12	Testing

Table B-12

Schedule of Training

Date	Crew	Time (Hours)	Training Activity
5 Dec 1978	ABLE	1300	Arithmetic & Monitoring
	ABLE	1400	Target ID & Monitoring
	ABLE	1500	Code Lock & Monitoring
	ABLE	1600	Combination of Tasks

Table B-13

Work Schedule During Week of Sleep Loss and Continuous Work

Date	Day of Week	Times of Work	Hours Worked
8 Jan 1979	Monday	0800 -- 1200	4
		1600 -- 2000	4
9 Jan 1979	Tuesday	0800 -- 1200	4
		1600 -- 2000	4
10 Jan 1979	Wednesday	0800 -- 2400	16
11 Jan 1979	Thursday	0000 -- 2400	24
12 Jan 1979	Friday	0000 -- 0800*	8
13 Jan 1979	Saturday	0800 -- 1200	4
		1600 -- 2000	4
14 Jan 1979	Sunday	0800 -- 1200	4
		1600 -- 2000	4
		Total Hours Worked	80

* A 24-hour rest and recovery period will begin at 0800 on this day. NOTE: The first 12 hours of the rest and recovery period must be spent in the Performance Assessment Laboratory.

BRASP-5: AGENDA AND SCHEDULES

The agenda and schedules used in Brasp-5 are presented on the following pages. They were distributed (along with the table presenting the basic 2-hr. task performance schedules) to the subjects during the orientation period on the afternoon of 9 February 1979.

Table B-14

General Schedule, BRASP-5

Date	Day (or Week)	No. of Hours	Activity
9 Feb 1979	Friday	4	Briefing
10 Feb 1979	Saturday	4	Training (Table B-15)
12-17 Feb 1979	Week #1	8-12	Testing
19-24 Feb 1979	Week #2	16-24	Testing
26 Feb - 3 March 1979	Week #3	16-24	Testing
5-11 March 1979	Week #4	80	Sleep Loss (Table B-16)
12-17 March 1979	Week #5	12	Testing
19-24 March 1979	Week #6	12	Testing
26-31 March 1979	Week #7	12	Testing
2-7 April 1979	Week #8	12	Testing
9-14 April 1979	Week #9	12	Testing

Table B-15

Schedule of Training

Date	Crew	Time (Hours)	Training Activity
10 Feb 1979	ABLE	0800	Arithmetic & Monitoring
	ABLE	0900	Target ID & Monitoring
	ABLE	1000	Code Lock & Monitoring
	ABLE	1100	Combination of Tasks

Table B-16

Work Schedule During Week of Sleep Loss and Continuous Work

Date	Day of Week	Times of Work	Hours Worked
5 March 1979	Monday	0800 -- 1200	4
		1600 -- 2000	4
6 March 1979	Tuesday	0800 -- 1200	4
		1600 -- 2000	4
7 March 1979	Wednesday	0800 -- 2400	16
8 March 1979	Thursday	0000 -- 2400	24
9 March 1979	Friday	0000 -- 0800*	8
10 March 1979	Saturday	0800 -- 1200	4
		1600 -- 2000	4
11 March 1979	Sunday	0800 -- 1200	4
		1600 -- 2000	4
		Total Hours Worked	80

* A 24-hour rest and recovery period will begin at 0800 on this day. NOTE: The first 12 hours of the rest and recovery period <u>must</u> be spent in the Performance Assessment Laboratory.

BRASP-6: AGENDA AND SCHEDULES

The agenda and schedules used in Brasp-6 are presented on the following pages. They were distributed (along with the table presenting the basic 2-hr. task performance schedules) to the subjects during the orientation period on the afternoon of 10 May 1979.

Table B-17

General Schedule, Brasp-6

Date	Day (or Week)	No. of Hours	Activity
10 May 1979	Thursday	4	Briefing
11 May 1979	Friday	4	Training (Table B-18)
14-19 May 1979	Week #1	24	Testing
21-26 May 1979	Week #2	24	Testing
28 May - 3 June 1979	Week #3	80	Sleep Loss (Table B-19)
4-8 June 1979	Week #4	12	Testing
11-14 June 1979	Week #5	12	Testing
18-22 June 1979	Week #6	12	Testing
25-29 June 1979	Week #7	12	Testing
2-6 July 1979	Week #8	12	Testing

Table B-18

Schedule of Training

Date	Crew	Time (Hours)	Training Activity
11 May 1979	ABLE	1300	Arithmetic & Monitoring
	ABLE	1400	Target ID & Monitoring
	ABLE	1500	Code Lock & Monitoring
	ABLE	1600	Combination of Tasks

Table B-19

Work Schedule During Week of Sleep Loss and Continuous Work

Date	Day of Week	Times of Work	Hours Worked
28 May 1979	Monday	0800 -- 1200	4
		1600 -- 2000	4
29 May 1979	Tuesday	0800 -- 1200	4
		1600 -- 2000	4
30 May 1979	Wednesday	0800 -- 2400	16
31 May 1979	Thursday	0000 -- 2400	24
1 June 1979	Friday	0000 -- 0800*	8
2 June 1979	Saturday	0800 -- 1200	4
		1600 -- 2000	4
3 June 1979	Sunday	0800 -- 1200	4
		1600 -- 2000	4
		Total Hours Worked	80

* A 24-hour rest and recovery period will begin at 0800 on this day. NOTE: The first 12 hours of the rest and recovery period <u>must</u> be spent in the Performance Assessment Laboratory.

BRASP-7: AGENDA AND SCHEDULES

The agenda and schedules used in Brasp-7 are presented on the following pages. They were distributed (along with the table presenting the basic 2-hr. task performance schedules) to the subjects during the orientation period on the afternoon of 27 July 1979.

Table B-20

General Schedule, Brasp-7

Date	Day (or Week)	No. of Hours	Activity
27 July 1979	Friday	4	Briefing
28 July 1979	Saturday	4	Training (Table B-21
30 July - 4 August 1979	Week #1	24	Testing
6-11 August 1979	Week #2	24	Testing
13-19 August 1979	Week #3	80	Sleep Loss Table B-22

Table B-21

Schedule of Training

Date	Crew	Time (Hours)	Training Activity
28 July 1979	ABLE	0800	Arithmetic & Monitoring
	ABLE	0900	Target ID & Monitoring
	ABLE	1000	Code Lock & Monitoring
	ABLE	1100	Combination of Tasks

Table B-22

Work Schedule During Week of Sleep Loss and Continuous Work

Date	Day of Week	Times of Work	Hours Worked
13 Aug 1979	Monday	0800 -- 1200	4
		1600 -- 2000	4
14 Aug 1979	Tuesday	0800 -- 1200	4
		1600 -- 2000	4
15 Aug 1979	Wednesday	0800 -- 2400	16
16 Aug 1979	Thursday	0000 -- 2400	24
17 Aug 1979	Friday	0000 -- 0800*	8
18 Aug 1979	Saturday	0800 -- 1200	4
		1600 -- 2000	4
19 Aug 1979	Sunday	0800 -- 1200	4
		1600 -- 2000	4
		Total Hours Worked	80

* A 24-hour rest and recovery period will begin at 0800 on this day. NOTE: The first 12 hours of the rest and recovery period <u>must</u> be spent in the Performance Assessment Laboratory.

APPENDIX C

DESCRIPTION OF BRASP SUBJECTS

Listed below are the study designators, subject numbers, sequential subject numbers employed in the text of this report, subject's position at the work station (and crew designation for BRASP-1, date of birth (and age at beginning of study), height, weight, marital status, and information pertaining to their menstrual cycle. For the BRASP-1 study where ten subjects were trained during Phase 1, additional subject position numbers are provided for those subjects who were selected to continue through Phase 2 and Phase 3.

BRASP-1

Subject 1.(1-1)--Charlie (the crew commander) on Able crew for Phases 1, 2, & 3 (C-1) was born on 7 December 1952; she was 25 years of age at the beginning of the study. Her height was 5'5", her weight was 115 lbs and she was unmarried. The gynecological examination reported she was normal and able to participate in the study. She was a normal cycling female not taking birth control pills. The subject began menstruating on 1 January 1978 and 2 February 1978 (prior to beginning of Phase 1), 9 March 1978 (MTPB Period A-15), and 13 April 1978 (MTPB Period 79). She was Day 14 of a 35-day cycle on MTPB Period 33.

Subject 2.(1-2)--Charlie (the crew commander) on Baker crew for Phase 1 (C-2) and subsequently Delta on Able crew for Phases 2 & 3 (D-2) was born on 8 September 1953; she was 24 years of age at the beginning of the study. Her height was 5'3½", her weight was 110 lbs, and she was married. The gynecological examination reported she was normal and able to participate in the study. She was a normal cycling female and not taking birth control pills. The subject began menstruating on 24 January 1978 (prior to the beginning of Phase 1) and 24 February 1978 (MTPB Period B-3), 30 March 1978 (MTPB Period 67), and 4 May 1978. She was Day 27 of a 34-day cycle on MTPB Period 33.

Subject 3.(3-1)--Alpha on Able crew for Phases 1, 2, & 3 (A-3) was born on 12 May 1957; she was 20 years of age at the beginning of the study. Her height was 5'5", her weight was 110 lbs, and she was married. The gynecological examination reported she was normal and able to participate in the study. She was taking birth control pills. The subject began menstruating on 6 January 1978 and 1 February 1978 (prior to beginning of Phase 1), 3 March 1978 (MTPB Period A-9), 31 March 1978 (MTPB Period 69), and 23 April 1978 (MTPB Period 89). She was Day 20 of a 28-day cycle on MTPB Period 33.

Subject 4.(n.a.)--Alpha on Baker crew for Phase 1 (A-4) was born on 11 November 1958; she was 19 years of age at the beginning of the study. Her height was 5'2", her weight was 101 lbs, and she was unmarried. She was a normal cycling female not taking birth control pills. The subject began menstruating on 31 January 1978 (prior to beginning of Phase 1), and 26 February 1978 (MTPB Period B-5). She was not selected for participation in Phases 2 & 3.

Subject 5.(n.a.)--Bravo on Able crew for Phase 1 (B-5) was born on 19 October 1956; she was 21 years of age at the beginning of the study. Her height was 5'8", her weight was 132 lbs, and she was unmarried. She was a normal cycling female not taking birth control pills. The gynecology physician recommended that the subject not be selected for participation in Phases 2 & 3 of the study since she had not yet began menstruating on the 37th day of her cycle. The subject began menstruating on 6 February 1978 (prior to beginning of Phase 1), and did not begin menstruating during Phase 1. She was not selected for participation in Phases 2 & 3.

Subject 6.(3-2)--Bravo on Baker crew for Phase 1 (B-6) and Bravo on Able crew for Phases 2 & 3 (B-6) was born on 20 September 1956; she was 21 years of age at the beginning of the study. Her height was 5'7", her weight was 125 lbs, and she was married. She was taking birth control pills. The gynecological examination reported she was normal and able to participate in the study. The subject began menstruating on 2 January 1978 and 30 January 1978 (prior to beginning of Phase 1), 26 February 1978 (MTPB Period B-5), 28 March 1978 (MTPB Period 65), and 26 April 1978 (MTPB Period 91). She was Day 25 of a 30-day cycle on MTPB Period 33.

Subject 7.(4-1)--Delta on Able crew for Phase 1 (D-7) and Echo on Able crew for Phases 2 & 3 (E-7) was born on 27 November 1957; she was 20 years of age at the beginning of the study. Her height was 4'11", her weight was 113 lbs, and she was unmarried. She was taking birth control pills. The gynecological examination reported she was normal and able to participate in the study. The subject began menstruating on 23 January 1978 (prior to beginning of Phase 1), 21 March 1978 (MTPB Period 31), and 18 April 1978 (MTPB Period 83). She was Day 2 of a 28-day cycle on MTPB Period 33.

Subject 8.(n.a.)--Delta on Baker crew for Phase 1 (D-8) was born on 10 August 1956; she was 21 years of age at the beginning of the study. Her height was 5'4", her weight was 125 lbs, and she was unmarried. She was taking birth control pills. The gynecological examination reported she was normal and able to participate in the study. The subject began menstruating on 1 February 1978 (prior to the beginning of Phase 1), and 1 March 1978 (MTPB Period B-7). She was not selected to participate in Phases 2 & 3.

Subject 9.(n.a.)--Echo on Able crew for Phase 1 (E-9) was born on 12 August 1958; she was 19 years of age at the beginning of the study. Her height was 5'8", her weight was 125 lbs, and she was unmarried. She was a normal cycling female not taking birth control pills. The subject began menstruating on 30 January 1978 (prior to beginning of Phase 1), and 27 February 1978 (MTPB Period A-5). She was not selected to participate in Phases 2 & 3.

Subject 10.(n.a.)--Echo on Baker crew for Phase 1 (E-10) was born on 28 October 1958; she was 19 years of age at the beginning of the study. Her height was 5', her weight was 96 lbs, and she was unmarried. She was a normal cycling female not taking birth control pills. The subject began menstruating on 3 February 1978 (prior to beginning of Phase 1), and 1 March 1978 (MTPB Period B-7). She was not selected to participate in Phases 2 & 3.

BRASP-2

Subject 11.(1-5)--Charlie (the crew commander) (C-1) was born on 21 November 1957; she was 20 years of age at the beginning of the study. Her height was 5'5", her weight was 120 lbs, and she was married. She was a normal cycling female and not taking birth control pills. The gynecological examination reported she had a 2-3 cm cyst on her right ovary, but that she was normal and able to participate in the study. A subsequent examination one month later found no trace of the cyst. The subject began menstruation 11 April 1978 (prior to the beginning of Phase 1), 14 May 1978 (MTPB Period 15), and 13 June 1978 (MTPB Period 78). She was Day 11 of a 30-day cycle on MTPB Period 33.

Subject 12.(1-3)--Alpha (A-3) was born on 11 October 1958; she was 19 years of age at the beginning of the study. Her height was 5'2½", her weight was 113 lbs, and she was unmarried. She was a normal cycling female and not taking birth control pills. The gynecological examination reported she was normal and able to participate in the study. The subject began menstruation 10 April 1978 (prior to the beginning of Phase 1), 9 May 1978 (MTPB Period 5), 8 June 1978 (MTPB Period 75), and 2 July 1978. She was Day 16 of a 30-day cycle on MTPB Period 33.

Subject 13.(1-4)--Bravo (B-5) was born on 20 August 1959; she was 18 years of age at the beginning of the study. Her height was 5'3", her weight was 159 lbs, and she was unmarried. She was a normal cycling female and not taking birth control pills. The gynecological examination reported she was normal and able to participate in the study. The subject began menstruation 2 April 1978 and 30 April 1978 (prior to beginning of Phase 1), and 31 May 1978 (MTPB Period 67). She was Day 25 of a 31-day cycle on MTPB Period 33.

Subject 14.(2-1)--Delta (D-7) was born on 25 February 1959; she was 19 years of age at the beginning of the study. Her height was 5'4", her weight was 110 lbs, and she was unmarried. She was a normal cycling female and not taking birth control pills. The gynecological examination reported that she had pain in both lower quadrants (abdomenal) and was referred to an internist. The internist reported that she was normal and able to participate in the study. The subject began menstruating on 21 January 1978, 23 February 1978, 23 March 1978, and 23 April 1978 (prior to beginning of Phase 1); 24 May 1978 (MTPB Period 36) and 25 June 1978 (MTPB Period 9). She was Day 1 of a 32-day cycle on MTPB Period 33.

Subject 15.(1-6)--Echo (E-9) was born on 4 February 1958; she was 20 years of age at the beginning of the study. Her height was 5'2", her weight was 107 lbs, and she was unmarried. She was a normal cycling female not taking birth control pills. The gynecological examination reported that she was normal and able to participate in the study. The subject began menstruating on 15 May 1978 (MTPB Period 15), 13 June 1978 (Period 77), and 9 July 1978. She was Day 10 of a 29-day cycle on MTPB Period 33.

BRASP-3

Subject 16.(2-2)--Charlie (the crew commander) (C-1) was born on 30 December 1954; she was 23 years of age at the beginning of the study. Her height was 5'3", her weight was 107 lbs, and she was married. She was a normal cycling female not taking birth control pills. The gynecological examination reported she was normal and able to participate in the study. The subject began menstruating 17 June 1978 (prior to beginning of phase 1), 19 July 1978 (MTPB Period 40) and 20 August 1978 (MTPB Period 89). She was Day 1 of a 32-day cycle on MTPB Period 33.

Subject 17.(4-2)--Alpha (A-3) was born on 2 March 1959; she was 19 years of age at the beginning of the study. Her height was 5'6", her weight was 130 lbs, and she was unmarried. She was taking birth control pills. The gynecological examination reported she was normal and able to participate in the study. The subject began menstruating on 19 June 1978 (prior to beginning of Phase 1), 18 July 1978 (MTPB Period 29), and 15 August 1978 (MTPB Period 85). She was Day 2 of a 28-day cycle on MTPB Period 33.

Subject 18.(4-3)--Bravo (B-5) was born on 20 September 1956; she was 21 years of age at the beginning of the study. Her height was 5'7", her weight was 122 lbs, and she was married. She was taking birth control pills. The gynecological examination reported she was normal and able to participate in the study. The subject began menstruating 20 June 1978 (prior to beginning of Phase 1), 18 July 1978 (MTPB Period 29), 15 August 1978 (MTPB Period 85), and 12 September 1978. She also served as Subject 6 (B-6) in BRASP-1. She was Day 2 of a 28-day cycle on MTPB Period 33.

Subject 19.(2-3)--Delta (D-7) was born on 11 April 1957; she was 21 years of age at the beginning of the study. Her height was 5'7", her weight was 128 lbs, and she was unmarried. She was a normal cycling female not taking birth control pills. The gynecological examination reported she was normal and able to participate in the study. The subject began menstruating on 23 May 1978 and 21 June 1978 (prior to the beginning of Phase 1), 20 July 1978 (MTPB Period 49), and 17 August 1978 (MTPB Period 89). She was Day 29 of a 29-day cycle on MTPB Period 33.

Subject 20.(n.a.)--Echo on Able crew (E-9) was born on 6 November 1958; she was 19 years of age at the beginning of the study. Her height was 5'4", her weight was 118 lbs, and she was unmarried. She was a normal cycling female not taking birth control pills. The gynecological examination reported she was normal and able to participate in the study. She began menstruating on 19 May 1978 (prior to the beginning of Phase 1), 25 June 1978, 16 July 1978 (MTPB Period 25), and 21 August 1978 (MTPB Period 89). She was Day 4 of a 36-day cycle on MTPB Period 33.

BRASP-4

Subject 21. (3-4)--Charlie (the crew commander) (C-1) was born on 19 May 1953; she was 25 years of age at the beginning of the study. Her height was 5'2", her weight was 105 lbs, and she was married. She was taking birth control pills. The gynechological examination reported she was normal and able to participate in the study. The subject began menstruating on 23 November 1978 (prior to the beginning of Phase 1), and 21 December 1978 (MTPB Period 9), 18 January 1979 (MTPB Period 69), and 15 February 1979. She was Day 21 of a 28 day cycle on MTPB Period 33.

Subject 22. (3-3)--Alpha (A-3) was born on 11 September 1958; she was 20 years of age at the beginning of the study. Her height was 5'7", her weight was 130 lbs, and she was single. She was taking birth control pills. The gynechological examination reported she was normal and able to participate in the study. The subject began menstruating on 5 November 1978 and 3 December 1978 (prior to the beginning of Phase 1), 1 January 1979 (MTPB Period 15), 28 January 1979 (MTPB Period 77), and 25 February 1979. She was Day 10 of a 27 day cycle on MTPB Period 33.

Subject 23. (404)--Bravo (B-5) was born on 31 May 1958; she was 20 years of age at the beginning of the study. Her height was 5'5", her weight was 108 lbs, and she was single. She was taking birth control pills. The gynechological examination reported she was normal and able to participate in the study. The subject began menstruating on 16 November 1978 (prior to the beginning of Phase 1), 14 December 1978 (MTPB Period 5), 11 January 1979 (MTPB Period 47), 8 February 1979 (MTPB Period 87), and 8 March 1979. She was Day 28 of a 28 day cycle on MTPB Period 33.

Subject 24. (3-5)--Delta (D-7) was born on 21 January 1959; she was 19 years of age at the beginning of the study. Her height was 5'9½", her weight was 135 lbs, and she was single. She was taking birth control pills. The gynechological examination reported she was normal and able to particpate in the study. The subject began menstruating on 1 November 1978 and 29 November 1978 (prior to the beginning of Phase 1), 27 December 1978 (MTPB Period 15), 23 January 1979 (MTPB Period 73), and 20 February 1979. She was Day 15 of a 27 day cycle on MTPB Period 33.

Subject 25. (3-6)--Echo (E-9) was born on 20 December 1958; she was 19 years of age at the beginning of the study. Her height was 5'8", her weight was 140 lbs, and she was single. She was taking birth control pills. The gynechological examination reported she was normal and able to participate in the study. The subject began menstruating on 1 November and 30 November 1978 (prior to the beginning of Phase 1), 29 December 1978 (MTPB Period 15), and 26 January 1979 (MTPB Period 76). She was Day 13 of a 28 day cycle on MTPB Period 33.

BRASP-5

Subject 26. (4-6)--Charlie (the crew commander) (C-1) was born on 13 October 1960; she was 18 years of age at the beginning of the study. Her height was 5'6½", her weight was 130 lbs, and she was single. She was taking birth control pills. The gynechological examination reported she was normal and able to participate in the study. The subject began menstruating on 9 January 1979 and 6 February 1979 (prior to the beginning of Phase 1), 6 March 1979 (MTPB Period 30), 3 April 1979 (MTPB Period 85), and 1 May 1979. She was Day 2 of a 28 day cycle on MTPB Period 33.

Subject 27. (n.a.)--Alpha (A-3) was born on 12 February 1959; she was 20 years of age at the beginning of the study. Her height was 5'3", her weight was 107 lbs, and she was single. She was normally cycling and not taking birth control pills. The gynecological examination reported she was normal and able to participate in the study. The subject began menstruating on 27 January 1979 (prior to the beginning of Phase 1), 27 February 1979 (MTPB Period 17), 26 March 1979 (MTPB Period 77), and 29 April 1979. She was Day 9 of a 27 day cycle on MTPB Period 33.

Subject 28. (4-5)--Bravo (B-5) was born on 11 January 1959; she was 20 years of age at the beginning of the study. Her height was 5'1", her weight was 95 lbs, and she was single. She was taking birth control pills. The gynechological examination reported she was normal and able to participate in the study. The subject began menstruating on 6 February 1979 (prior to the beginning of Phase 1), 6 March 1979 (MTPB Period 31), 4 April 1979 (MTPB Period 86), and 1 May 1979. She was Day 2 of a 29 day cycle on MTPB Period 33.

Subject 29. (4-7)--Delta (D-7) was born on 19 September 1955; she was 23 years of age at the beginning of the study. Her height was 5'0", her weight was 100 lbs, and she was single. She was taking birth control pills. The gynechological examination reported she was normal and able to participate in the study. The subject began menstruating on 10 January 1979 and 7 February 1979 (prior to the beginning of Phase 1), 7 March 1979 (MTPB Period 33), 4 April 1979 (MTPB Period 85), and 1 May 1979. She was Day 1 of a 28 day cycle on MTPB Period 33.

Subject 30. (2-4)--Echo (E-9) was born on 16 February 1960; she was 18 years of age at the beginning of the study. Her height was 5'3", her weight was 100 lbs, and she was single. She was normally cycling and not taking birth control pills. The gynecological examination reported she was normal and able to participate in the study. The subject began menstruating on 11 January 1979 and 7 February 1979 (prior to the beginning of Phase 1), 6 March 1979 (MTPB Period 31), 2 April 1979 (MTPB Period 83), and 1 May 1979. She was Day 2 of a 27 day cycle on MTPB Period 33.

BRASP-6

Subject 31. (1-7)--Charlie (the crew commander) (C-1) was born on 31 July 1960; she was 18 years of age at the beginning of the study. Her height was 5'2", her weight was 100 lbs, and she was single. She was normally cycling and not taking birth control pills. The gynecological examination reported she was normal and able to participate in the study. The subject began menstruating on 16 April 1979 and 9 May 1979 (prior to the beginning of Phase 1), 4 June 1979 (MTPB Period 65), 29 June 1979 (MTPB Period 87), and 28 July 1979. She was Day 22 of a 26 day cycle on MTPB Period 33.

Subject 32. (n.a.)--Alpha (A-3) was born on 10 February 1959; she was 20 years of age at the beginning of the study. Her height was 5'0", her weight was 160 lbs, and she was single. She was normally cycling and not taking birth control pills. The gynecological examination reported she was normal and able to participate in the study. The subject began menstruating on 30 March 1979 and 30 April 1979 (prior to the beginning of Phase 1), 10 June 1979 (MTPB Period 71), and 2 July 1979 (MTPB Period 89). She was Day 31 of a 41 day cycle on MTPB Period 33.

Subject 33. (n.a.)--Bravo (B-5) was born on 10 December 57; she was 21 years of age at the beginning of the study. Her height was 5'9", her weight was 120 lbs, and she was single. She was normally cycling and not taking birth control pills. The gynecological examination reported she was normal and able to participate in the study. The subject began menstruating on 29 April 1979 (prior to the beginning of Phase 1), 10 June 1979 (MTPB Period 71), and 9 July 1979. She was Day 32 of a 42 day cycle on MTPB Period 33.

Subject 34. (3-7)--Delta (D-7) was born on 12 September 1960; she was 18 years of age at the beginning of the study. Her height was 5'3", her weight was 130 lbs, and she was single. She was taking birth control pills. The gynechological examination reported she was normal and able to participate in the study. The subject began menstruating on 19 April 1979 (prior to the beginning of Phase 1), 17 May 1979 (MTPB Period 7), 14 June 1979 (MTPB Period 75), and 16 July 1979. She was Day 14 of a 28 day cycle on MTPB Period 33.

Subject 35. (3-8)--Echo (E-9) was born on 6 November 1958; she was 20 years of age at the beginning of the study. Her height was 5'4", her weight was 125 lbs, and she was single. She was taking birth control pills. The gynechological examination reported she was normal and able to participate in the study. The subject began menstruating on 10 May 1979 (prior to the beginning of Phase 1), 7 June 1979 (MTPB Period 69), and 5 July 1979. She was Day 21 of a 28 day cycle on MTPB Period 33.

BRASP-7

Subject 36. (4-8)--Charlie (the crew commander) (C-1) was born on 20 November 1957; she was 21 years of age at the beginning of the study. Her height was 5'6", her weight was 104 lbs, and she was single. She was taking birth control pills. The gynecological examination reported she was normal and able to participate in the study. The subject began menstruating on 19 June 1979 and 17 July 1979 (prior to the beginning of Phase 1), and 14 August 1979 (MTPB Period 29). She was Day 2 of a 28 day cycle on MTPB Period 33.

Subject 37. (n.a.)--Alpha (A-3) was born on 22 August 1955; she was 23 years of age at the beginning of the study. Her height was 5'8½", her weight was 180 lbs, and she was married. She was normally cycling and not taking birth control pills. The gynechological examination reported she was normal and able to participate in the study. The subject began menstruating on 20 June 1979 and 19 July 1979 (prior to the beginning of Phase 1), 17 August 1979 (MTPB Period 53), and 17 September 1979. She was Day 27 of a 29 day cycle on MTPB Period 33.

Subject 38. (n.a.)--Bravo (B-5) was born on 7 April 1957; she was 22 years of age at the beginning of the study. Her height was 5'7", her weight was 110 lbs, and she was single. She was normally cycling and not taking birth control pills. The gynecological examination reported she was normal and able to participate in the study. The subject began menstruating on 15 June 1979 and 13 July 1979 (prior to the beginning of Phase 1), 9 August 1979 (MTPB Period 19), and 7 September 1979. She was Day 7 of a 29 day cycle on MTPB Period 33.

Subject 39. (n.a.)--Delta (D-7) was born on 21 July 1960; she was 19 years of age at the beginning of the study. Her height was 5'7", her weight was 112 lbs, and she was single. She was normally cycling and not taking birth control pills. The gynecological examination reported she was normal and able to participate in the study. The subject began menstruating on 12 July 1979 (prior to the beginning of Phase 1), 11 August 1979 (MTPB Period 23), and 8 September 1979. She was Day 5 of a 28 day cycle on MTPB Period 33.

Subject 40. (2-5)--Echo (E-9) was born on 1 July 1957; she was 21 years of age at the beginning of the study. Her height was 5'6", her weight was 135 lbs, and she was single. She was normally cycling and not taking birth control pills. The gynecological examination reported she was normal and able to participate in the study. The subject began menstruating on 18 July 1979 (prior to the beginning of Phase 1), 14 August 1979 (MTPB Period 29), and 10 September 1979. She was Day 2 of a 27 day cycle on MTPB Period 33.